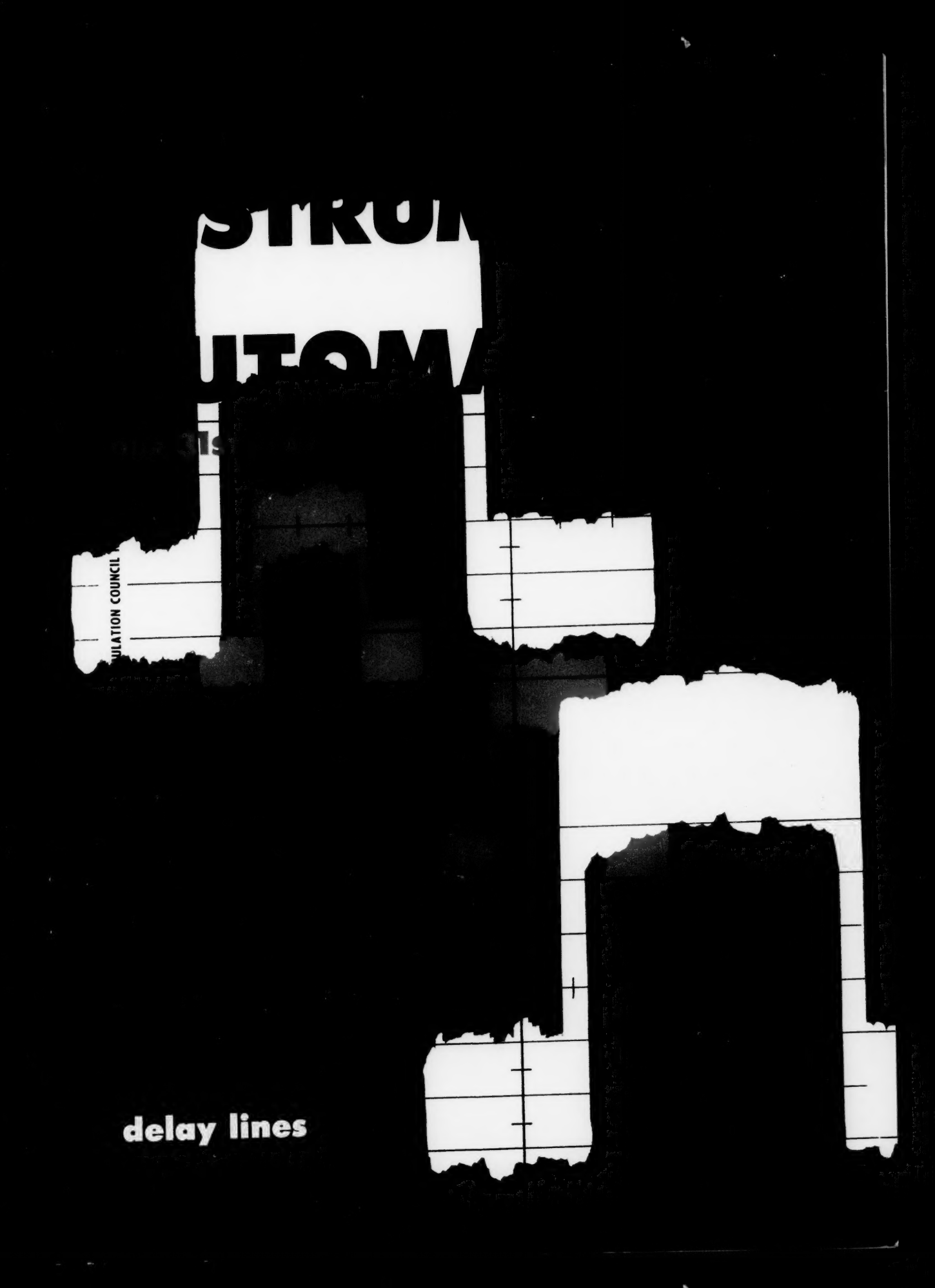
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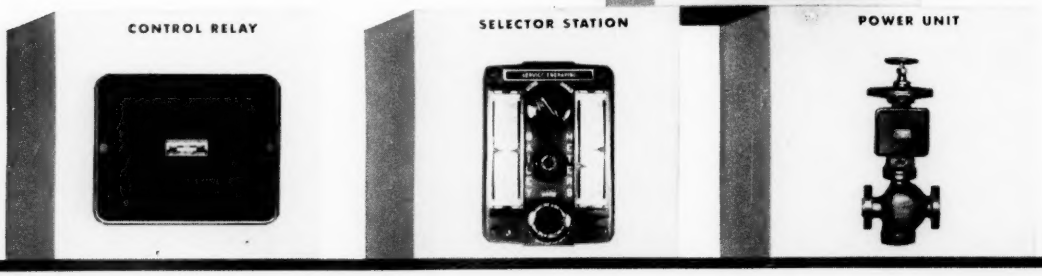
For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.



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BAILEY METER COMPANY
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In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

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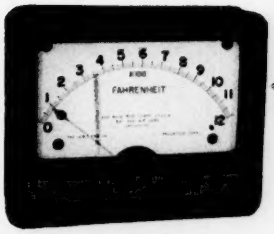
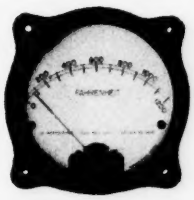


MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.

MODEL 62RT4

THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

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RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

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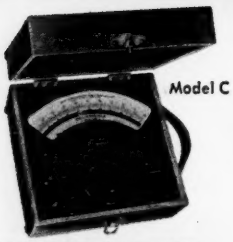
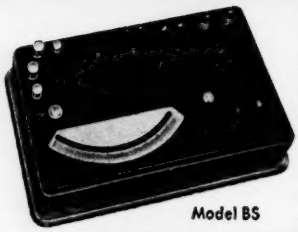

Model C

POLYRANGERS

Multirange DC Reference Standard .25% accurate current and voltage measuring instrument. 14 ranges from 1.5 ma. and 3V. to 3 amps. and 750 V. 6.3" scale length. Other Polyrangers with as many as 88 ranges self-contained available for AC or AC-DC use.

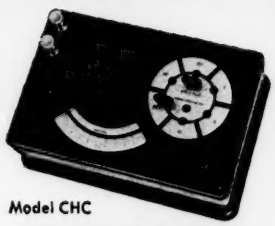

Model BS

Model THACH

LABORATORY STANDARDS

"Self Checking" DC Volt-Amp-Milliammeter. .05% accurate. 12" vernier scale. 25 full scale ranges from 1.5 ma. and .3 V. to 15 amps. and 1500 V. Internal standard cell. Other DC laboratory standards available with an accuracy of .1% and full scale ranges starting from 30 microamps or 50 mv.

"Self Checking" Volt-Amp-Milliammeter. Accuracy .2% DC and AC 7 cps — 4 kcps. 6.3" scale length. 19 full scale ranges from 10 ma. and 1 volt to 5 amps. and 1000 V. Internal standard cell. Other AC standards available with an accuracy of .1% with full scale ranges from 10 ma. and 10V.


Model CHC

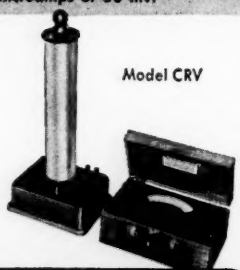
AMMETERS

Heavy current DC use. .2% accurate. Self-contained. Ranges switched by changing a single-plug connection. 6.3" scale length. Full scale ranges between 1 and 100 amps. Other instruments available as millivoltmeters with external laboratory standard shunts. Ranges up to 1,000 amps.

Model FM

FLUXMETERS

Single or multirange. Basic sensitivity 10,000 maxwells per division using a single turn search coil. Accuracy .5%. 5.2" scale length. Available with general purpose 10 turn search coil with a mean area of 8 square centimeters.


Model CRV

CREST VOLTMETERS

Measures RMS, positive and negative peaks of 10 per second or faster. Basic instrument is electrostatic voltmeter with accuracy of 1%. Ranges up to 100 KV. full scale. Input impedance 10,000 megohms. For AC or repetitive pulsed DC.

Model FRE

FREQUENCY METERS

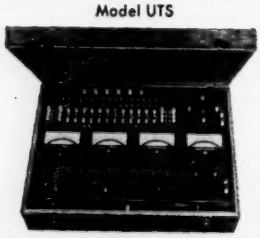
Expanded scale, direct reading, single and multirange low audio frequency measuring instruments of the differential coil permanent magnet type. Accuracy .25%. 6.3" scale length.

Model RFV

VOLTMETERS

True RMS responding. Full scale ranges from 1 V. to 300 V. Accuracy .5% on DC to 1 megacycle. Usable up to 10 megacycles. Other thermocouple instruments available for all current and voltage measurements.

Model UTS



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Replaces over 200 individual DC current, voltage and resistance measuring instruments. Accuracy .5%. Contains 3 instruments that may either be a millivoltmeter, voltmeter, milliammeter, or ammeter, and 1 microammeter. Portable. Other test sets available for AC and magnetic testing.

Model UPP

Type EW

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For more information circle 3 on inquiry card.

INSTRUMENTS AND AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—MHA

PART I
OCTOBER 1958

VOLUME 31 NO. 10

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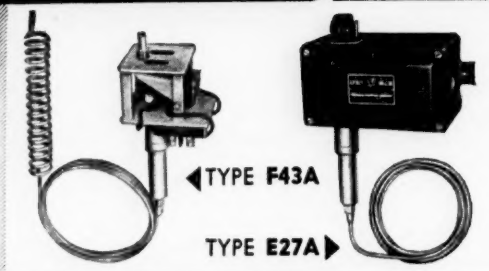
Dual Switch
REMOTE BULB
TEMPERATURE CONTROLS

F43A | E27A



The F43A and E27A are functionally similar units that are offered by UNITED ELECTRIC for applications where it is desirable to control two separate circuits at different temperatures by means of a single temperature control. The major differences between the two units are that the F43A is an uncalibrated, wide range, skeleton unit while the E27A is calibrated, has a narrow range, and is enclosed. If desired, the E27A can be modified to have a wide range.

Temperature Ranges . . . F43A — up to maximum limits of −150° to +150°F., 70° to 370°F., or 100° to 650°F.
E27A — 100° or 200°F. spans between −150° and +650°F. limits.

On-Off Differential . . . . Approximately 1.0°F. or 2.0°F. depending upon the model.

Switch Ratings . . . . . . Up to 15 amps. at 115 or 230 volts A.C. 20 amps. A.C. or D.C. switches also available.

Switch Types . . . . . . N.O., N.C., or Double Throw — no neutral position.

Adjustments . . . . . . F43A — slotted range adjustment screw on top, uncalibrated settings. E27A — external knob and pointer, calibrated settings.
In each unit, switch may be adjusted individually to provide for approximately 15°F. max. span between switch settings. Span remains constant over entire range.

Electrical Connections . . Via attached terminal blocks.

Capillary Tube Length . . 6-foot standard length. Other lengths available.

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E27A — via mounting ears or tapped holes.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. For special applications, standard units may be modified, or custom-built units may be provided. For additional data on remote type temperature controls, including types F43A and E27A, request* Section 200 *of our* new *catalog.*

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89 SCHOOL STREET, WATERTOWN, MASS

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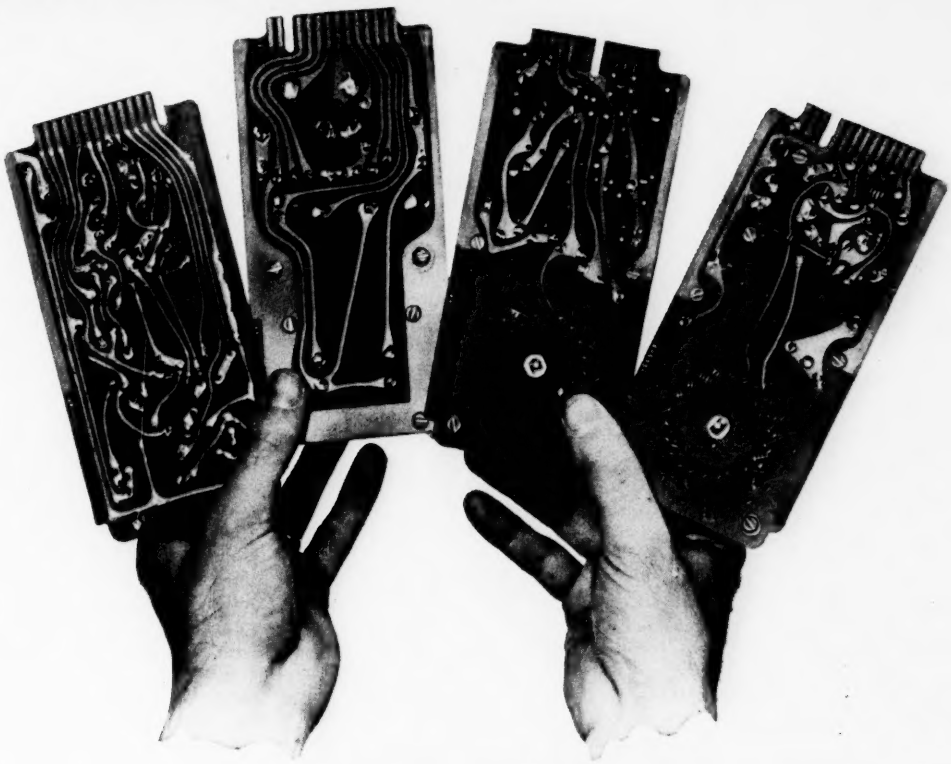

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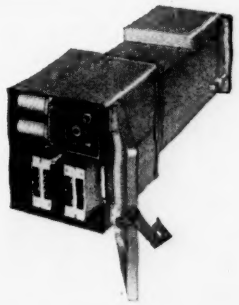

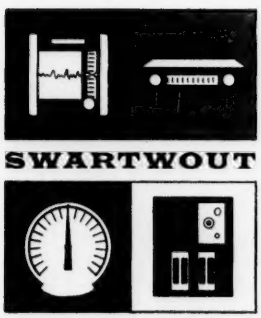

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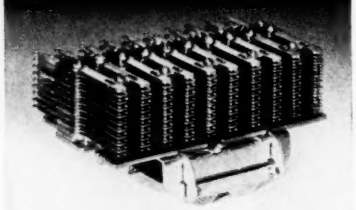

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to the editor

Editor, I&A:

It has been interesting to read the fine comments from some of your many thousands of readers, congratulating your thirty years of service.

I am apparently a newcomer, having read your publications for only twenty years. Looking back to the time when your publication, *Instruments*, was the only source of information an instrument man had to find out what was going on in the instrument world about him, it seems, progresswise, like 150 years ago—but in reality it was only a few years.

Your efforts and fine selection of articles have been a real contribution and education to many an instrument man, and an inspiration to the entire field as well. Your ability to stay ahead in an ever-changing industry has been truly remarkable.

The tremendous thirst for knowledge, the ever-advancing science, the new concepts of systems engineering and the rapidly growing data handling instruments challenge the imagination of man.

We look to the sky, with our thoughts on the future, and to *Instruments & Automation* for a "look see" for the instruments of tomorrow as the curtain is being drawn on space and beyond.

Congratulations on your past accomplishments. Good luck to your tremendous future.

Wm. H. Haney, Systems Eng'r.
Chance Vought Aircraft
Northern Calif. I. S. A.

Russian Report

Editor, I&A:

Your readers might be interested in learning about my experience gained as a member of the American Automatic Control Council delegation. I must preface these notes with a statement that the following are personal opinions based only on a limited knowledge available to me as a visitor during 14 days of visiting Russian plants. However, and this is the point which I should like to stress, the 14 days were filled with many visits to individual factories with 3,000 and more employees ranging from watch manufacturing to scientific laboratories, industrial instruments companies, motion picture studio equipment manufacturers, ball-bearing and automobile plants, power stations, and steel mills. Thus, they represent a rather broad section of the industrial spectrum.

The delegation was a guest of the Russian Government's Scientific Technical Committee and, therefore, many doors were opened to it which otherwise would have been closed to the individual visitor.

Ever since Russian industry rebuilt itself through improvisation out of the rubble of cities destroyed in the war, its managers have operated in an atmosphere of planned production with little regard for potential consumer demand. They are not concerned with competition; their schedules are laid out for several years, and they don't worry about sales.

This situation offers a great opportunity for any engineer, or manager, to show what he can do. The success of these people expressed in rate of increase of production and quality produces a mental climate of pride, relaxed goodwill and confidence in the future.

The Russian plant manager seems to enjoy a great amount of freedom, with corresponding responsibility, in running his plant, and appears to be exposed, since Stalin's death at least, to a minimum of political interference. We were told by several managers that they sit down with their company union and the Government Planners to arrive at reasonable schedules for each 5-year plan.

These plans cover facilities expansion and employment planning, and seem to be tailored realistically enough so that only in a few exceptional cases have the assigned goals not been reached. Fulfillment of the plan is made more desirable by wide and generous use of a rather capitalistic bonus system consisting roughly of about 20% additional pay for fulfilling the plan and "n" times the % of exceeding the plan—with n varying from ½ to 4 depending on industry, city, and the position of the employee.

There are many other fringe benefits and cash bonuses for saving production cost, improving products and increasing plant capacity, in addition to honorable display of the employee's photo at an honor billboard under red flags and a picture, or bust, of Lenin.

One of these benefits are cash bonuses to be applied to the building of new apartments, which are scarce.

In their endeavor, management appears to be singularly supported by the dedication and effort of the workers who (even if they have no other choice) seem to work at a rate which is unusually high. This effort—in which women share without the least discrimination but also without any

privileges, as one finds them even on the toughest foundry jobs—is so much more remarkable because the working conditions, illumination, safety space and tools leave much to be desired when compared with US standards.

Instruments are available for any measuring and control application. These are basic components and assemblies without the packaging frills essential in a competitive system and without the latest gadget features. As their production is based on several years' schedules, they are by necessity somewhat behind those of our latest.

Centralized research and development as practiced in the USSR has advantages in avoiding duplication, and in profiting by picking the fruits of Western technology. At this stage of the game, Russia's engineers are lagging slightly behind Western designs. The similarity of Russian and U. S. designs which we noted in the plants visited suggested the sterility which is inherent in this system.

This does not mean that in areas where they decided to go ahead (as in Sputnik), they cannot successfully do so, but with such tremendous basic needs of their own and other communist satellites, plus China, there is no particular rush to produce pioneer lines.

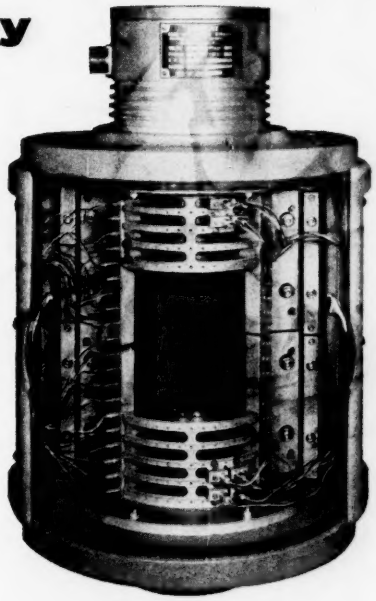
In spite of all statements to the contrary, consumer goods are scarce to a degree unthinkable for Westerners. There are very few items at GUM, the big department store, one can buy. Either the price expressed in salary hours is too high (the throttle used by the Government to prevent buying) or the quality is too low to make the products desirable. A photo-electric exposure meter sells for 190 Rubles (nearly one-fourth the basic monthly income of a laborer) and a wrist watch sells for 450 Rubles.

This produces—with the accumulation of unspent bonuses—a new middle class which sooner or later will insist on having its needs taken care of.

It also produces a black market (as it did under similar conditions in other countries) which could become a danger to the economy, particularly when Russian women will wake up to demand their share of the luxuries of life.

Of interest to instrument people may be the wide use of conveyor assembly lines in instruments and precision component plants. There the answer to the visitor's "why?" appears to be a scarcity of skilled labor

Improve Your Memory



with a standard multiple purpose off-the-shelf drum

The 512-A Bryant general purpose magnetic storage drum meets the exacting requirements of a production component, yet has the versatility necessary for laboratory work. This standard 5" dia. x 12" long drum is stocked for immediate shipment, complete with standard components such as general storage brackets, recirculating register brackets and magnetic read/record heads. Its low price reflects the benefits of Bryant's 25 years' experience in the efficient design and production of high speed precision spindles.

Features:

- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less
- Integral drive—Bryant precision motor (1200 to 12,000 R. P. M.)
- Capacities to 625,000 bits
- Accommodates up to 240 magnetic read/record heads
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble free operation

Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R. P. M. can be attained, with frequencies from 20 C. P. S. to 5 M. C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512-A booklet, or for special information.

Remember . . . you can't beat a Bryant drum!

BRYANT COMPUTER PRODUCTS DIVISION

BRYANT CHUCKING GRINDER CO.

P. O. Box 620-I, Springfield, Vermont, U.S.A.

For more information circle **7** on inquiry card.

... for automatic process quality control

Introducing the

Brookfield VISCOMETRAN

Easily installed under any conditions in tanks, vats, or production systems, the new Viscometran continuously measures vital viscosity. Combined with any standard recorder, the unit can either automatically signal the danger or activate controlling devices to prevent variations.

An unusually flexible sanitary instrument, the Viscometran will measure either Newtonian or non-Newtonian type materials from emulsions, suspensions, and slurries to fiber bearing products.

Now viscosity control can mean quality control! It will pay you to find out more about the economical, easily maintained Brookfield Viscometran. Complete information is yours without obligation by return mail. Write, wire, or phone — or tear out and mail this whole ad, using the coupon below.

Brookfield
ENGINEERING LABORATORIES, INC.
STOUGHTON 316, MASSACHUSETTS

Send more information to.....

.....

For more information circle 8 on inquiry card.

LETTERS—CONTINUED

and the conviction that the production engineering invested in conveyor methods pays for itself in more uniform quality and in better designs.

We saw potentiometer recorders leaving the conveyor at a rate of one every 4 minutes, with about 200 assembler girls, and were told that even 2-day runs were found to justify conveyor assembly lots.

The contrast of the Russian atmosphere to that of the well-stocked Helsinki department store, and to that of the ISA show with its variety of equipments from various companies, impresses one more than ever with the advantages of a competitive society, and with the problems the USSR will have to face in bridging the present gap between production and potential demand.

H. Ziebolz
General Precision Equipment Corp.
New York, N. Y.

Editor, I&A:

Our Company has been retained by the ICA to design, supervise, and furnish the necessary technical assistance for a water system project which includes treating, storage and distribution facilities, and waste water collection, treatment and disposal for the cities of Dacca and Chittagong, East Pakistan.

Plans include the immediate establishment of an office in Dacca which will be staffed by a big team of American and Pakistani engineers.

There will be a technical library, and water-chemical and bacteriological laboratories which are expected to be operated permanently by the Government of Pakistan.

We will appreciate it if you will notify your advertisers that catalogs and literature will be welcome at the library. Material should be posted, via surface mail, to The Ralph M. Parsons Co., Dacca, East Pakistan.

A. W. Moore
Ralph M. Parsons Co.
Los Angeles, Calif.

Editor, I&A:

Please accept profound condolences of our governing and editorial boards on occasion of sudden departure of your esteemed Major Behar in whom we shall always honour a founding pioneer of our common scientific endeavour: instrumentation.

Hungarian Scientific Society For Measurement and Automation
Meres Es Automatica
Budapest, Hungary

At the Brussels Fair IBM's Ramac presents World History in 10 languages with the help of Skinner Solenoid Valves

Visitors to the World's Fair at Brussels are given the opportunity to submit history questions to IBM's Ramac and get their answers in any one of ten languages. Millions have been fascinated by this amazing electronic data processing machine.

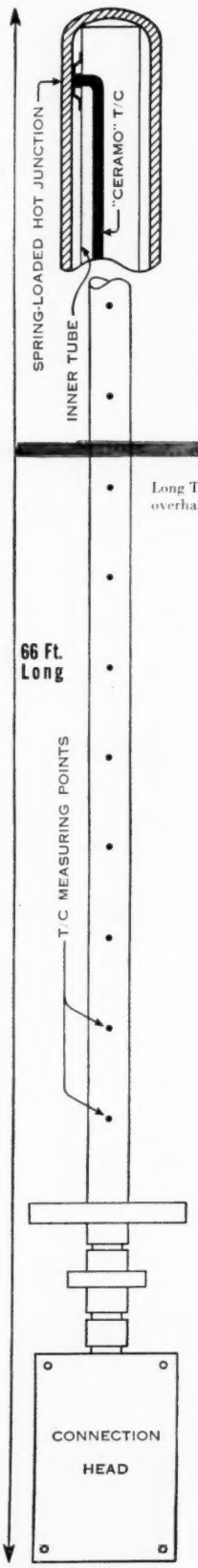
Ramac is a vast library of facts. By means of 50 rotating metal disks 5,000,000 alphamerical characters can be stored and selected at the touch of a button. The Ramac can punch 100 cards a minute, transfer data from punch cards to disks at a rate of 125 cards per minute, and print reports at speeds up to 80 lines per minute.

Three Skinner V5 three-way valves are used in the access control mechanism. One valve engages the access arm at the exact location of the disk, while the second valve disengages the arm after the read-write sequence has been completed. The third valve positions the read-write head at the precise location on the proper disk tract.

Skinner has a wide selection of solenoid valves for all types of applications. If you have a control problem, why not take it to a Skinner engineer or representative. You will find Skinner representatives listed in the Yellow Pages or write direct to Department 410.

SKINNER ELECTRIC VALVE DIVISION NEW BRITAIN CONNECTICUT

For more information circle 9 on inquiry card.



66 Ft. Multi-Thermocouple Shipped to South Africa

Three Long Multi-Thermocouples, Totaling 194 Feet Sent Across Ocean By Thermo Electric

Long T/C Assemblies overhang trailer

Thermo Electric makes thermocouples for just about every possible application—including some pretty unusual ones. The multi-thermocouple assembly diagrammed here is a good example. It's 66 feet long.

The longest of three, this assembly has a total immersion length of 63'7". The entire unit actually contains 12 different thermocouples—in progressively longer lengths from 9'1" to 63'7". These are enclosed in a 1½" I.P.S., Schedule 80 protection tube of type 304 Stainless Steel. Individual thermocouple construction is of T-E's "Ceramo"—ceramic insulated conductors encased in overall metal sheathing. O.D.'s are ⅛" with 22 gage Iron-Constantan conductors. Hot junctions are welded closed and, for fast response, are spring-loaded against the inner wall of the protection tube.

The three assemblies were sent by T-E to Durban, South Africa for installation in a catalyst reactor. They are typical of what Thermo Electric is currently doing in the field of temperature measurement. T-E equipment is being used all over the world for important temperature measuring jobs. Assemblies like this, used in deep vessels, will measure temperatures at any desired level. Thermo Electric also makes miniature thermocouples as small as ½" immersion length. Whatever your needs, for large or small thermocouples, for low or extremely high temperatures, for any type of application, contact Thermo Electric. Our extensive research, engineering and manufacturing facilities are at your disposal.

Write For Detailed Information

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

For more information circle **10** on inquiry card.

Reader Inquiries

Use of Magnetic Tape and Wire as Trigger

Engineer desires information on the use of magnetic tape and wire to trigger relays, etc. A-339

Address Sought

Reader wishes to locate Optronics whose last address was P. O. Box 3152, Inglewood, Calif. A-340

Mercury

Reader requests information on (1) how many pounds there are in a standard flask of Hg, (2) which companies make flasks, (3) names of large companies using Hg, and (4) trade books on Hg. A-341

Gear Pullers

Engineer in mechanical-components manufacturing company would like to find sources for the supply of instrument gear pullers. A-342

Running Torque Meter

President of company manufacturing telephone equipment would like to purchase meter for small motors having approximately 2 oz in torque. A-343

Timing Belt and Helical Gears

Purchasing agent of compressor manufacturer wishes to contact makers of timing belts and/or helical gears for use in a speed-increasing unit. A-344

Vacuum Pump

University professor of chemistry would like to purchase completely leakproof circulating pump for pure heavy nitrogen isotope gas without packing glands. Must pump minimum of 0.25 liters/sec at 10mm Hg. Magnetic drive or the like is desirable. A-345

Miniature Hydraulic Tube Fittings

Manager of instrument lab requests information on suppliers of miniature hydraulic tube fittings from ⅛" OD tubing down to capillary sizes, *not* regular IPS fittings. A-346

Pipe-Fitting Lock Nut

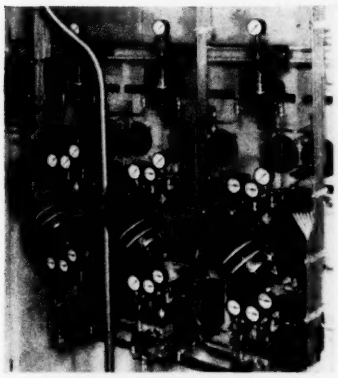
President of instrument manufacturing company wishes to find manufacturers of pipe-fitting lock nut (*not* tube fitting) carrying "O" ring for seal. A-347

Technical Writer

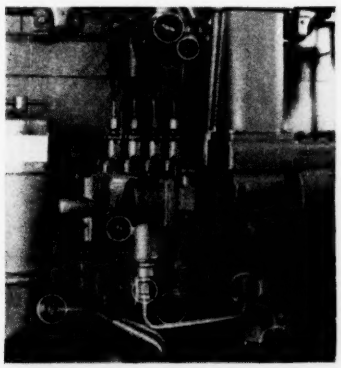
Advertising agency requests contact with technical writer in the midwest who could write for one of its clients. A-348

Cut installation time 36 to 77%

with IMPERIAL Hi-Duty® tube fittings

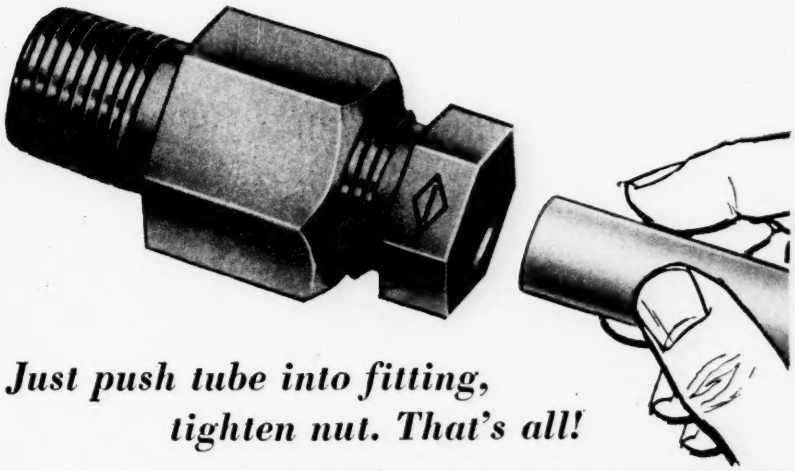


Rear view of a graphic panel used to control a Platform® Unit, built by Panellit Inc., Skokie, Ill.



Millions of Hi-Duty fittings in use on O.E.M., instrumentation and replacement jobs. Hi-Duty fittings can be disconnected and reconnected repeatedly without danger of leakage. Extra-strong forged bodies on elbows and tees, long Dryseal pipe threads and generous hexes. Available in brass and aluminum. For use with copper, brass, aluminum, Bundyweld, GM, block tin, Monel and other metal tubing — ⅛ to 1" O.D.

For complete data, ask for Bulletin No. 3002.



Just push tube into fitting, tighten nut. That's all!

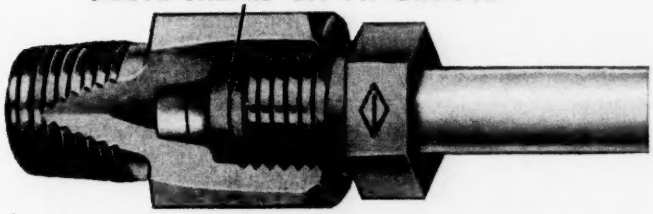
Whether you use 10 Hi-Duty fittings or 500 per installation, seconds saved per fitting will quickly add up to man-hour profits!

Four-to-one edge over flared fittings — A man can easily assemble up to four Hi-Duty fittings in the time it takes to assemble *one* flare fitting. Spot tests show only 11.7 seconds on the average are required to install Hi-Duty as compared with 48.2 seconds for an ordinary flare fitting. A minimum 77% boost in efficiency for you.

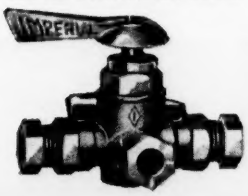
One-third faster than compression fittings — Same tests showed Hi-Duty installation required only 11.7 seconds compared with an average of 18.5 for compression fittings. A boost of 36% in efficiency!

Hi-Duty joints absorb 5 times as much vibration as compression or flare fittings — Sleeve on Hi-Duty fittings shears off during assembly and becomes permanently attached to tube. Always remains in perfect alignment. Joints stay liquid-and-gas tight.

SLEEVE SHEARS OFF AT GROOVE



Furnished in Brass and Aluminum



Hi-Duty® SHUT-OFF VALVES — First choice for perfect fluid control! Positive shut-off. Solid bottom — no chance for leakage. Spring-loaded stem with "O" ring seal maintains proper tension on nickel-silver plug at all times. 2, 3 and 4-way types for low and medium pressures.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard Street, Chicago 48, Illinois

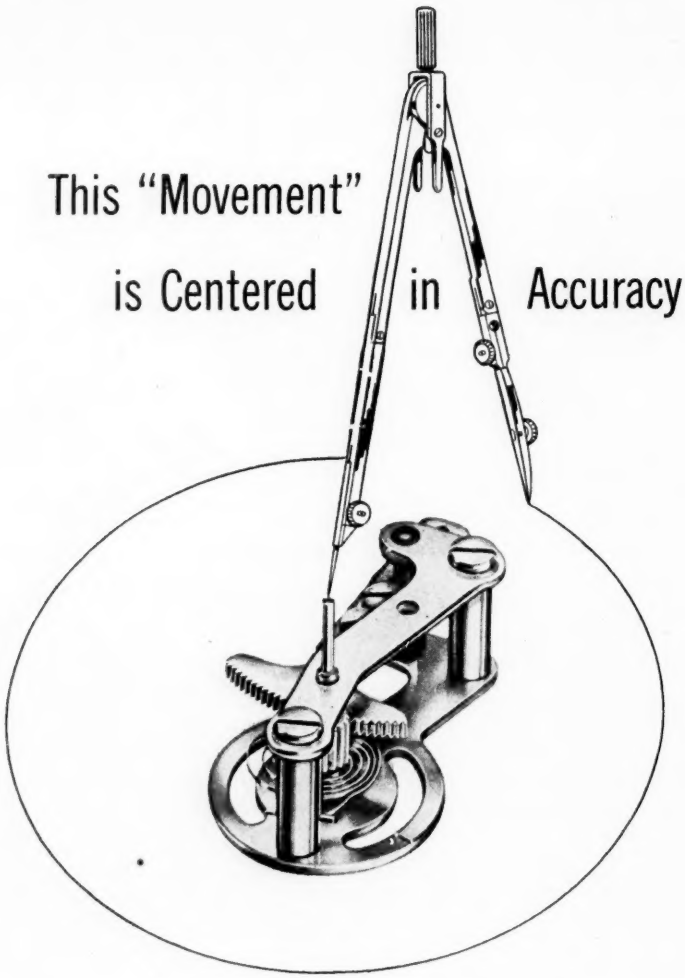
Dept. IA 108
***In Canada:* 18 Hook Avenue, Toronto, Ontario**

Emblem of Quality I

SEE YOUR IMPERIAL DISTRIBUTOR — he carries the industry's most complete line of tube fittings and tubing tools.

For more information circle **11** on inquiry card.

This "Movement" is Centered in Accuracy



The rotary movement in Ashcroft Duragauges has a geared center shaft on which the pointer is mounted. When pressure flexes the Bourdon tube, the pointer is always positively positioned. You can rely on the Duragauge for precise accuracy in measuring pressure no matter how severe the conditions of service.

Correct calibration is guaranteed: the one-piece link between movement and Bourdon tube prevents slippage or parting under tension. Recalibration is easy from front or rear. Universal adjustability permits uniformly graduated dials.

You can order Ashcroft Duragauges with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. A complete choice of Bourdon tube materials, pressure ranges, dial sizes and case designs and materials is available. Your industrial supply distributor will gladly help you select the best combination for your requirements. So, be certain of highest sustained accuracy, durability and economy – specify Ashcroft Duragauges.

Ashcroft Duragauge in Alumalife® case—a lifetime case made of special aluminum alloy.

MAXWELL M&M MANNING & MOORE, INC. TRADE MARK

G1-58

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **12** on inquiry card.

Domestic mercury consumption in USA in 1957 was 52,889 flasks (76-pounds each); compared to 54,143 in 1956. Most mercury is imported from Spain and Italy (25,994 flasks from Spain in 1957; 9,208 from Italy; 5,990 from Mexico). Domestic production in 1957 was 33,380 mine flasks; 5,800 secondary flasks; imports were 45,449 flasks; exports were 1,919 flasks. Average N. Y. price per flask in 1957 was $246.98; average in first quarter of 1958 was $224.75. Data are from Mercury Report 126, Bureau of Mines, Mineral Industry Surveys.

Tantalum capacitor sales are estimated to have doubled from 1956 total of $10 million to 1957 total of $20 million, owing to increasing use in military equipmment.

Analysis of six state governments (Calif., Conn., N. M., N. Y., N. Car., and Wisc.) by the National Science Foundation reveals that these six spent $69 million for scientific activities, of which $57 million was for R&D, divided as follows: agriculture--$20.5 million; state universities--$16.8 million; health and welfare--$8.4 million; resource development and public works--$7.7 million; legislative and judicial—$1.3 million; business, labor and vocational licensing--$1.3 million; education--$0.5 million; fiscal control--$0.4 million; public safety--$0.08 million.The $69 million total was 2% of total expenditures of the states for all purposes; $15 million of total was contributed by Federal government.

There are currently about 150 manufacturers listed as producers of printed circuits, reports Institute of Printed Circuitry; 25 to 30 experienced and qualified manufacturers are producing 90% of the total non-captive volume of business.

There are commercially available about 20,000 physical laboratory items (instruments and apparatus), plus about 20,000 chemical reagents, reports SAMA.

There are more than 565 independent scientific laboratories in the United States performing industrial R&D, reports SAMA.

Annual cost of operating a research reactor (including salaries of staff, utilities, health physics, maintenance, insurance, fuel and amortization) may range from as low as $15,000 per year for a fractional-watt laboratory reactor to more than $200,000 for a 1000-kw pool reactor, reports AEC. Special facilities may cost as much as the reactor, and have comparable operating expenses.

There are more than 1500 different scientific and technical professional groups and societies in the USA and Canada.

Market for high-vacuum equipment exceeds $20 million annually, reports A. D. Little, Inc.

In 1910, ratio of production workers in production to those in service trades (professions, maintenance, cleaning, etc.) was 3:1. Today it is 1:1.

THE NEW *ADVANCED DESIGN*

MI 606 D/R OSCILLOGRAPH

HAS ALL OF THESE FEATURES . . . .

FLASH TIMING up to 1,000 CPS

ALL PURPOSE VERSATILITY with 5 Magazine Types

RECORDING SPEEDS .071 to 173 IPS (or as slow as 3 inches per minute on order)

TRACE WRITING SPEEDS to 75,000 IPS

FREQUENCY RESPONSE to 5,000 CPS

GRID LINES Linear Log or Special to Order

SHARP FOCUS TRACE LINES at All Speeds

RECORDS THREE WAYS—on Direct Readout Paper,

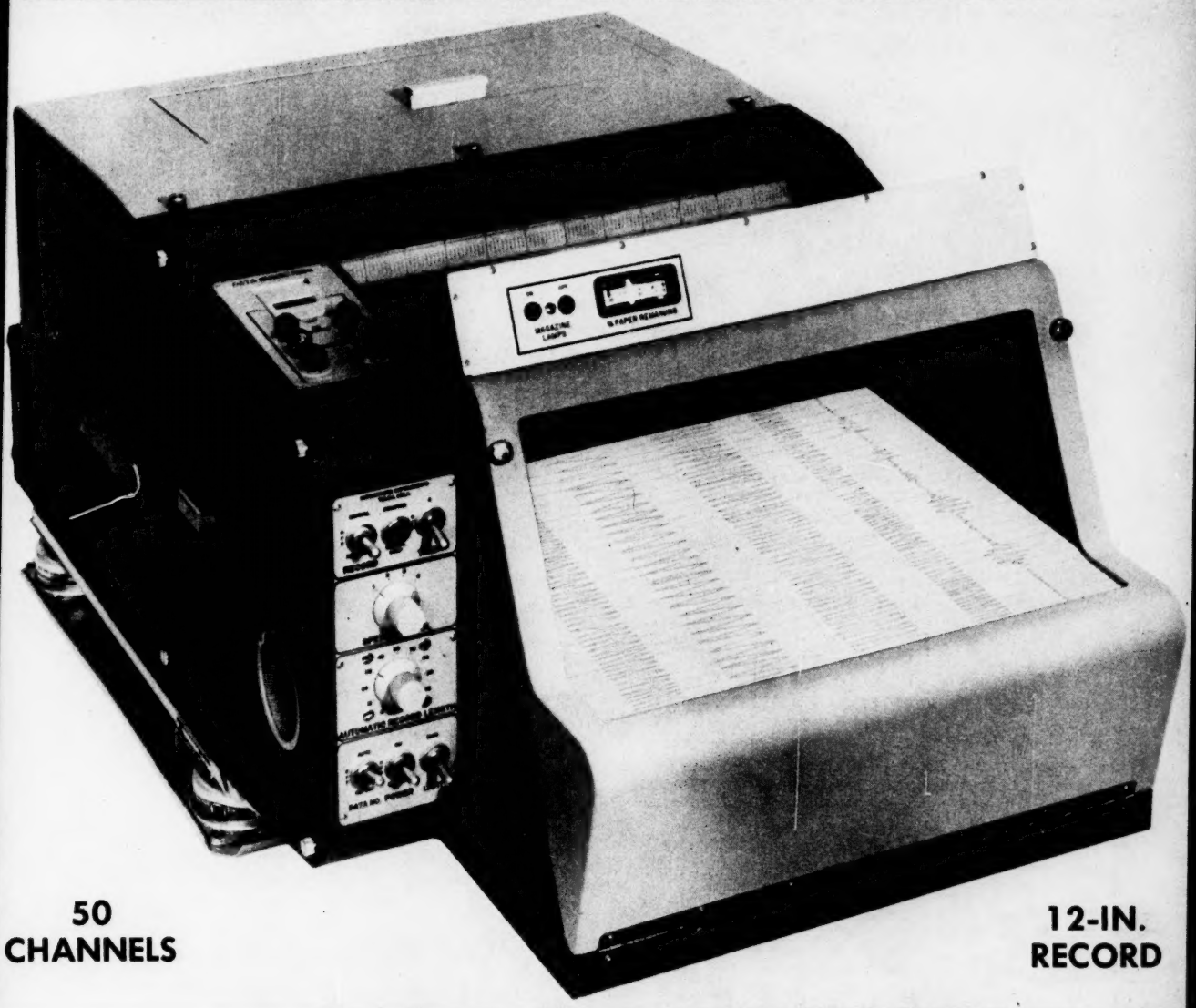
For more information circle **13** on inquiry card.

MI MIDWESTERN INSTRUMENTS

"LEADING THE ADVANCEMENT OF THE ART" . . .

. . . is an accurate description of the 606 Direct Recording Oscillograph which is indeed a tribute to the creative talents of Midwestern's engineers.

Various research and development programs of the United States Armed Forces and an equally great number of laboratories in private industry regularly depend on test information supplied through the use of Midwestern's instruments. Performance of the 606 D/R places it in a position of preeminent importance in these fields.



50 CHANNELS

12-IN. RECORD

Illustrated with Model 248 Magazine

Photographic Paper or Photographic Film

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41ST AND SHERIDAN / TULSA, OKLAHOMA

news

Operating Guide Computer Goes On-Line

PHILADELPHIA, PA.—An Operating Guide Computer System—the first installation of its kind in the process industries—has been successfully placed on-line at a catalytic cracking unit at Esso's Baton Rouge Refinery. Engineered and constructed by Leeds & Northrup,

the system measures 160 process variables of which 27 are computed operating guides such as catalyst circulation rate, carbon burning rate, material balance, etc. The system incorporates a Royal Precision LGP-30 general purpose digital computer. In addition to calculating operating guides, the system prints out off-normal conditions, and furnishes on-demand, hourly, and daily log-sheet summaries of process operation.

Cryostat for Precise Temperature Control

WASHINGTON, D. C.—The Cryogenic Engineering Lab of the NBS Boulder (Colo.) Labs has developed a cryostat for low-temperature research on electronic elements such as a quartz crystal oscillator frequency standard.

By employing several convenient liquefied gases successively as refrigerants, the cryostat controls the temperature of an electronic element over a wide range of temperatures—at essentially any value between the boiling point of liquid helium and room temperature. Accuracy of control ranges from approximately 0.01° to 0.001°F. Electric resistance thermometers or thermostats in bridge circuits automatically adjust the electric heat input to balance exactly the heat loss to the cooler environment.

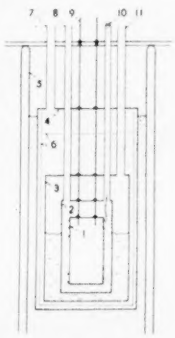


Diagram shows "oven" (1) which is insulated by vacuum held in (2). The liquefied gas refrigerant contained in (3) is protected from room temperature by vacuum container (4) and radiation shields (6).

Jones & Laughlin Starts Continuous-Weld Pipe Mill

PITTSBURGH, PA.—J & L has been practicing continuous-weld pipe welding for about a year in its Aliquippa Works. With the opening of the second mill in late June the process was shown to the press: A total investment of $18½ million in the two mills will yield greater production and finer products than from the two

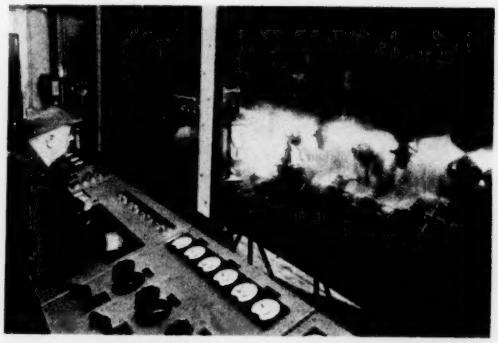


FIG. 1. OPERATOR in air-conditioned control room sends signals to forming and welding stands.

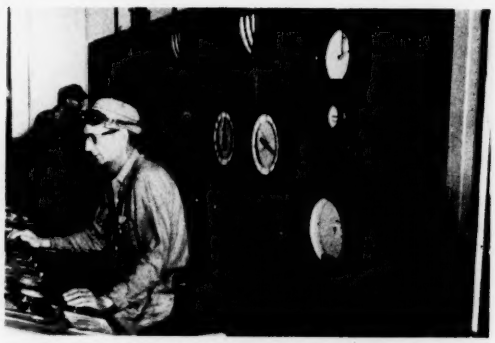


FIG. 2. CONTROL PANEL keeps automatic watch on temperatures, pressures, etc.

butt-weld mills constructed in 1926. Instrumentation covers mainly temperature measurements and controls (such as temperature of furnace, waste gas, skelp, etc.) for which Minneapolis-Honeywell, Leeds & Northrup, ATC, and others furnished the instruments, as well as BTU, air and flue pressure measurements shown on Republic indicators. The welding and forming stands are controlled from a console.

West European Plants to Have U. S. Computers

BRUSSELS, BELGIUM—Bendix Aviation Corp. reports a keen interest displayed by a great number of European countries in the G-15 digital computer, like the one being demonstrated at the American Pavilion of the Brussels Exposition. Italy, Germany and Belgium are interested in the computing equipment that provides shortcuts to problems in aircraft and guided missile programs. "Several hundred authentic major industrial inquiries" have been received to date, from all European countries in attendance at the exposition, reports Bendix.

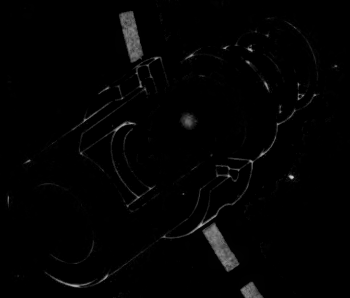
PERFECT SURFACE . . . EXTREME HARDNESS . . . LOW COST

—all this and more, with LINDE Sapphire!

To assure dependability under the most severe conditions, tiny valve poppets and seats of pilot relief valves for space vehicle tanks built by Whittaker Controls are made from LINDE Sapphire. LINDE Sapphire was selected over other materials for this critical use because of its perfectly smooth surface, extreme hardness, and relatively low cost. Other advantages are resistance to corrosion and fast deliveries from LINDE.

Among other properties of LINDE Sapphire are zero porosity, great strength at elevated temperatures, and a high melting point of 2040° C. LINDE Sapphire is transparent, may be clear or red. It is easily sealed to metals or ceramics and has excellent IR transmission characteristics.

LINDE Sapphire is supplied in the form of balls, rods, tubes, domes, and special shapes to order. For more information, write Crystals Department, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.



Pilot section of this pressure relief valve has poppet ball, red, and seat of LINDE Sapphire. Valve was designed and manufactured by Whittaker Controls Division of Telecomputing Corporation.

Linde and Union Carbide are registered trade marks of Union Carbide Corporation.

Linde

UNION CARBIDE

For more information Circle

because . . .
our business is the
design and manufacture of
temperature measuring
instruments . . .
and has been since 1867.

Close to 90 years
of experience in this field
has made the name of
MOELLER the standard of
accuracy and reliability.

For information on these
precision products
made by Moeller
mail the coupon, today.

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Thermo-Wells, Separable Sockets, Thermo-Couple Protecting Wells and Tubes.

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FIRM .....
ADDRESS .....
CITY ..... ZONE..... STATE.....

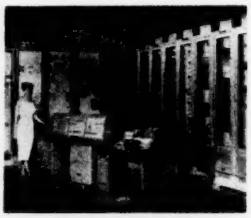
For more information circle **15** on inquiry card.

News Bits

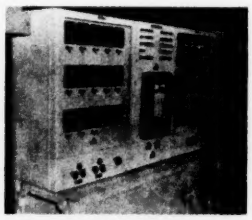
AUTOMATED CHEMISTRY LAB built by Britain's Baird and Tatlock Ltd., will collect samples; mix and meter reagents and samples; heat and agitate solutions; run color, titration, potentiometric, etc. tests; graph results; wash equipment; sound alarm or make automatic corrections in process.

BATTELLE scientists are studying the properties of three semiconductor compounds—indium phosphide, gallium arsenide, and aluminum antimonide—for use in transistors and rectifiers operating in high temperature and nuclear environments. Companies jointly sponsoring the research include: Erie Resistor Corp., General Electric Co., International Business Machines Corp., Ohio Semiconductors, Inc., Philco Corp., Sarkes Tarzian, Inc., and Texas Instruments, Inc.

EECo has delivered the digitizing system for Project DATUM of the Centralized Data Processing Facility, Air Force Flight Center, Edwards Air Force Base. One of the largest military-type data processing facilities in the U. S., it provides rapid automatic data processing of test aircraft, rocket engine, and radar data gathered during flight tests.—ECCo also announces receipt of an order for a Computer Language Translator (from Systems Development Corp.) to translate computer data into a common language acceptable by most existing computers.



EECO Digitizing System



DEVCON
programmer & recorder

DEVCON has designed a new programmer and recorder system for pilot plant production of gasoline by catalytic reforming. The machine has been installed in the process laboratories of Esso Research and Engineering Co., Linden, N. J.

THIRD EIA CONFERENCE ON RELIABLE ELECTRICAL CONNECTIONS to be held in Dallas December 2, 3 and 4, 1958 will bring an innovation, in that papers will not be read by their authors, but will be available for sale October 15 so that questions can be prepared which will be answered at the conference.

LAMP DIVISION OF GE is using a **BENDIX AVIATION** G-15 computer to solve radiation problems involving temperature changes in wire filaments and filament vibration of electric light bulbs.

An International **CONVENTION ON TRANSISTORS** and Associated Semi-Conductor Devices will be held in London's Earls Court from May 25 to 29, 1959. Sponsored by the Radio and Telecommunication Section of the Institution of Electrical Engineers it will be accompanied by an International Exhibition. Address Industrial and Trade Fairs Ltd., Drury House, Russell Street, London W. C. 2, England for information.

ASA has published new standards for Outlet Receptacles, Attachment Plug Caps, and Appliance Plugs, designated C73.1-1957.

new RotoRelay works like a motor in...

ELECTRONIC #4 RELAY

Electronic Relay Model #4 is the most important advance in the design of highly sensitive electronic relays for the control of relatively large amounts of power. Every conceivable relay improvement is embodied in this new instrument. It is designed with the new RotoRelay which employs a mercury-to-mercury contact in a completely sealed steel chamber.

RotoRelay employs a sealed mercury switch tube which is tilted to the open-circuit or closed-circuit position by a highly efficient magnetic circuit. There is no sliding plunger within the mercury tube. This means you get *positive action* . . . no danger of sticking or breaking! The d.c. power input for reliable operation of RotoRelay with a 35-amp mercury tube is less than one watt, compared with four watts for a mercury plunger relay.

Also you achieve direct current in the control circuit. You can use unlimited lead wires to your control, making it independent of capacitance changes. The control circuit operates with micro currents.

The Electronic Relay Model #4 is in a corrosion resistant case convenient for permanent installation or bench use with a 15 amp line cord and power receptacle.

For complete information, write for Bulletin

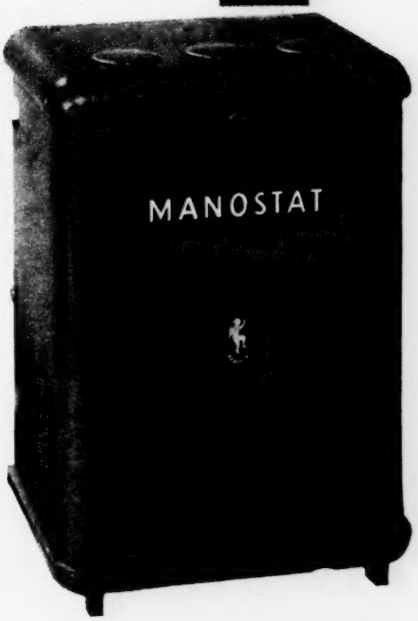


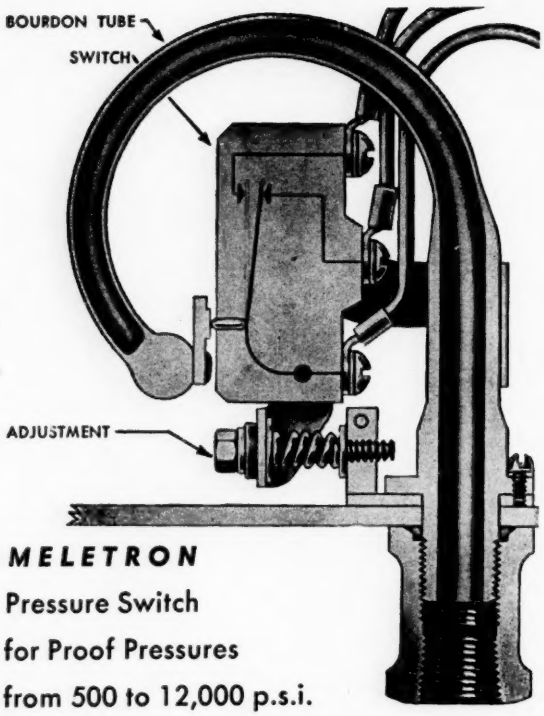
TABLE OF RELAY CHARACTERISTICS — Model #4

Load Current	35 amps. 115 volt AC
Control Voltage	7 volts DC open circuit
Control Current	2 microamps DC closed circuit
Catalogue No.	24875
Price	115

The EMIL GREINER Co.

20-26 N. MOORE STREET DEPT. 230 N. Y. 13, N. Y.

For more information circle **16** on inquiry card.



MELETRON

Pressure Switch

for Proof Pressures

from 500 to 12,000 p.s.i.

Competes on Price

Wins on Accuracy

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS

which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete specifications and operating data ask for bulletins 302 to 382.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

For more information circle **17** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

	Price Range For 1958 Thur 9/16/58 HIGH	LOW	Price As of 9/16/58
ACF Industries	45 1/2	37 1/8	40
Aerequip Corp.	21 7/8	16 7/8	19 1/2
Allis Chalmers	28	22 1/8	27 1/2
American Chain & Cable	49 3/8	39 1/2	40 1/2
American Machine & Foundry	44 5/8	32 1/4	44 5/8
American Machine & Metals	60	47 1/2	60
American Optical	39 1/8	34 3/4	36
American Tel.& Tel.	188 3/4	167 7/8	186 1/4
Beckman Instruments	26 3/4	18 1/8	25 1/2
Bell & Howell	72 3/4	42	72
Bendix Aviation	61 3/8	44 1/2	57 3/4
Boeing Airplane	47 3/4	34 1/8	46 1/4
Bullard	17 1/4	10	15 5/8
Bulova Watch	14	9 3/4	12 3/8
Burroughs	37 3/4	27 5/8	36 5/8
Carborundum	37 5/8	30 7/8	35
Cincinnati Milling Machine	40 1/4	27	39
Clevite	21 1/2	15 3/4	21 3/8
Columbia Broadcasting "A"	36 3/8	24 1/2	34 1/8
Consolidated Electrodynamics	35 1/2	27 7/8	34 3/4
Consolidated Electronics	26 3/4	19 1/2	23 5/8
Cornel Dubilier	18 5/8	12 3/4	18-18 1/2 (1)
Corning Glass	95	74 5/8	94 7/8
Curtiss-Wright	31 1/2	20 5/8	28 7/8
Cutler-Hammer	59	40 1/2	57
Daystrom	39 1/4	30	37 3/4
Douglas Aircraft	74 7/8	54 1/2	59 1/4
Eastman Kodak	131	97 1/8	126 1/4
Eaton Manufacturing	55 1/4	38 1/2	55
Electric Auto Lite	37 1/8	25	36 1/4
Elgin Watch	9 3/4	6 3/4	8 1/2
Emerson Electric	42 3/8	29	41 7/8
Food Machinery & Chemical	70	47 1/2	68
General Dynamics	32 1/8	20 1/2	30 1/8-30 1/2 (1)
Garrett	44 1/2	27	42 1/2
General Electric	65 3/4	55	61 1/2
General Instrument	68 3/4	57	68
General Mills	10 3/4	4 5/8	10 1/4
General Precision Equipment	85	60 1/4	80 7/8
General Railway Signal	41	27	29 1/4
General Telephone	31 1/8	21 1/8	29
General Controls	53 3/8	40 3/8	51 7/8
General Time	19 5/8	14	17 3/4
General Tire & Rubber	24 3/4	16 5/8	24 5/8
International Bus. Machines	30	22 1/4	26 3/4
	410	300	410

(1) Not Traded - Bid and Asked

International Tel. & Tel.	45	29 1/4	44 1/2
I-T-E Circuit	42	30 1/8	41 1/8
Litton Industries	59 1/4	36 7/8	57 5/8
Lockheed Aircraft	54 3/4	38 3/8	54 3/8
Magnavox	42 1/4	30 1/4	41 3/4
Mallory	34 1/4	23 5/8	33 1/2
Minneapolis-Honeywell	101 1/2	76	100
Minneapolis Mining & Mfg.	97 3/4	73 1/2	96 3/4
Motorola	48 1/4	35	47 3/4
National Acme	57 3/4	43 7/8	57 3/4
National Cash Register	74 3/4	50 1/2	74 1/4
North American Aviation	36 3/4	25 5/8	36 3/8
Northrop Aircraft	28 5/8	22 1/8	28 1/4
Otis Elevator	59	40 1/4	57 5/8
Philco Corp.	22 3/8	12 3/8	21 3/4
Radio Corp. of America	39 5/8	30 1/4	39
Raytheon	40 1/4	21 1/2	39 1/2
Reliance Electric	43	31	43
Rheem Mfg.	15 1/2	10 1/2	13 5/8
Robertshaw-Fulton	29 3/4	22 1/4	26 7/8
Royal McBee	21	16	20
Sangamo Electric	34 3/4	25	28
Sperry Rand	21 1/8	17 1/4	19 5/8
Square D	27 1/2	20 1/8	27 1/4
Standard Coil Products	10 3/8	6	9 3/8
Starrett (L.S.)	74 3/4	57	66 1/2-67 (1)
Stewart-Warner	39 3/8	29	39
Sylvania Electric	43 3/8	31 1/2	43 1/4
Telautograph	7 7/8	3 3/4	6 5/8
Texas Instruments	50 1/2	26 3/4	46 1/8
Thompson Products	60 3/4	41 3/8	58 1/4
Tung-Sol Electric	29 3/4	23 1/4	28 3/8
Underwood Corp.	22	12 7/8	20 1/8
Union Carbide Corp.	113	83 7/8	111 1/2
United Shoe Machinery	46 3/4	32	46 5/8
Western Union	27 1/2	15	26 3/4
Westinghouse Air Brake	26 3/8	17 7/8	25 3/4
Westinghouse Electric	65 1/2	55 1/2	64 1/2
Worthington Corp.	61 7/8	45 1/4	59 3/4

(1) Not Traded - Bid and Asked

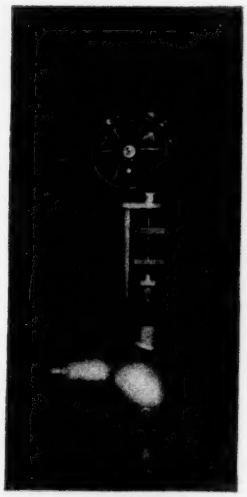
Continued on page 1618

FOR SPEEDY INFORMATION

Slow down long enough to note there is a key number at the end of product and literature reviews and at the foot of each ad. To speed more information your way, circle the corresponding number on the inquiry card bound in this issue. If the card has already been used, simply write the key number, the date of issue, and your name and address on a postal card and send c/o our Reader Service Dept.

CONTROL VALVES BY CONOFLOW

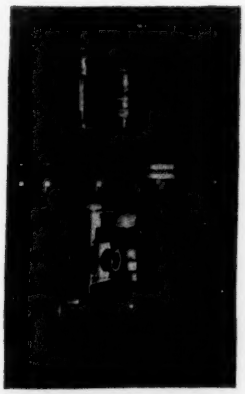
YEARS AHEAD IN DESIGN



SERIES S CONTROL VALVES

Specifically designed to handle the tough services which cause ordinary valves to fail.

- Sizes to 14"; pressure ratings to 2500 lbs.
- Extra heavy body construction exceeds ASA standards.
- Self-sealing bonnet will not leak regardless of temperature or pressure conditions.
- Patented Rotomotor actuator handles large sizes with high power requirements.



SERIES HB SAUNDERS VALVES

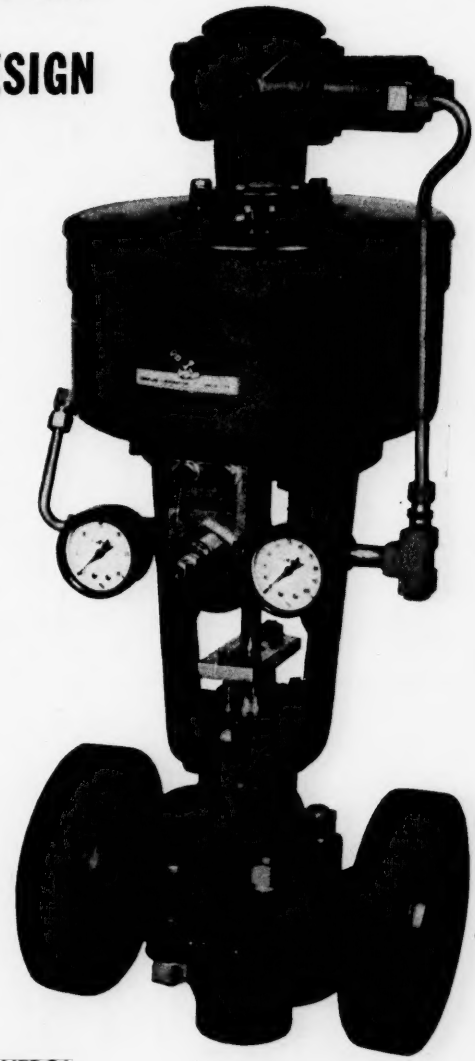
Original close-coupled design introduced by Conoflow has long been an industry standard.

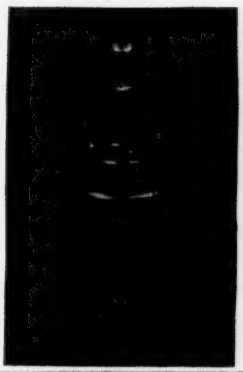
- Completely engineered factory assemblies assure premium performance.
- Actuators for on-off or throttling control in all valve sizes.
- Exclusive Bonnet Loading System available for higher thrust outputs.
- Compact construction allows for more economical piping arrangements.

SERIES LB CONTROL VALVES

Quality construction and truly integrated body-actuator design completely outmodes conventional control valves.

- Cono J Positioner sets new industry standards for precise proportional positioning.
- Rugged cylinder actuator utilizes sturdy metal piston and exclusive lipseals which cannot leak.
- Single-seat body design guarantees positive, tight shut-off under any conditions.
- "Lift-out" seat ring can be replaced quickly with a minimum of effort.
- Extra thick body walls give added protection against corrosion and erosion.
- Simplified construction means less replacement parts and substantial inventory savings.





SERIES AB CONTROL VALVES

A line of economical control valves for handling small flows.

- Bodies available in two and three-way design, in all alloys.
- Extra long stroke; double that of conventional valves.
- Suitable for high pressures and corrosive services.
- Completely enclosed spring-over-diaphragm construction is compact and protects spring from atmospheric corrosion.

When you specify Conoflow control valves you get the best valve available for your control application. Write for literature or let us put you in touch with a Conoflow representative qualified to help solve your control problems. Conoflow Corporation, Dept. C-805, 2100 Arch Street, Philadelphia 3, Pa.

Cono Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

Subsidiary of Walworth

For more information circle **18** on inquiry card.

MARSHALLTOWN

DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **19** on inquiry card.

American Stock Exchange: *Continued from page 1616*

Price Range For 1958 Thru 9/16/58

	HIGH	LOW	PRICE AS OF 9/16/58
American Meter	36	27 5/8	34 1/2
Arc Equipment	19 1/2	13 3/4	19
Barry Controls "B"	8 7/8	4 3/8	8 1/2-8 5/8(1)
Bolock Instruments	11 3/4	7 3/8	10
Bearns Watch	6 7/8	4 7/8	3 1/4
Breese Corp.	7	5 1/8	6 7/8
Clark Controller	19 1/2	14 7/8	18 1/4
Clarostat Mfg.	4 3/8	2 7/8	3 7/8
Clary Corp.	5	2 7/8	4 1/8
Dumont Laboratories	5 5/8	3	3 3/4
Dynamics Corp. of America	4 1/2	2 7/8	4 1/4
Electronics Corp. of America	8 1/2	6 3/8	8 1/4
El-Tronics	3 1/8	1 5/8	2 5/8
Fairchild Camera & Instrument	31 5/8	19 1/2	27 1/4
Globe-Union	17 1/4	14 5/8	15 7/8-16 3/8 (1)
Hazeltine Corp.	49 1/2	30 1/2	47 5/8
International Resistance	5 7/8	3 3/4	5 1/4
Lear, Inc.	7 1/2	4 1/4	7 1/8
National Research	17 3/8	12 7/8	14 7/8
Neptune Meter	30 1/8	19 1/2	29 5/8
New Haven Clock	3 1/4	7/8	1 1/8
Norden-Ketay	6 1/8	2 3/4	3 1/8-3 1/4(1)
Nuclear Corp. of America	1 1/2	7/8	1
Pneumatic Scale	36	18 1/2	31 1/4
Servo Corp. of America	6 3/4	3 3/4	6 5/8
Servomechanisms	11 1/8	6 5/8	9 1/2
Wallace & Tiernan	28	24	27 5/8
Waltham Prec. Instrument Co.	1 1/2	13/16	1 3/8

1) Not Traded - Bid and Asked

Over-The-Counter

	QUOTATION AS OF 9/16/58	
	BID	ASKED
Aerovox Corp.	5 1/8	5 5/8
Aircraft Radio Corp.	22 1/2	23 3/4
Argus Corp.	24 1/2	25
Eitel-McCullough	24	25
Electronics Associates	46 3/4	48
Erie Resistor Corp.	7 1/4	7 3/4
Fisher Governor Company	16 1/8	16 3/4
Foxboro Company	42 1/4	44 1/2
G.M.Giannini	17	18 1/8
Industro Transistor	2 1/4	2 3/4
Liquidometer Corp.	6 1/8	6 5/8
W. L. Maxson	6 5/8	7 5/8
Penn Controls, Inc.	16 3/4	17 3/4
Speer Carbon, Inc.	27 3/4	29
Sprague Electric	34 1/2	35 3/4
Taylor Instrument	29	30
Telecomputing Corp.	4 5/8	5 1/4
Topp Industries	8 3/4	9 1/4
Varian Associates	26 3/8	27
Vitro Corp. of America	13 7/8	14 5/8

EQUIP FOR THE SIZE OF THE JOB

The Levin micro-drilling equipment shown here can be used with the smallest drills available. It is designed so that the drilling does not depend on the operator's sense of feel. The drill can be retracted for chip removal and returned to the drilling position without striking the bottom of the hole. While commercial drills can be had as small as .0016" this micro-drilling apparatus has successfully produced holes as small as .0006". Send for catalog M describing complete line of instrument lathes and accessories. Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, California.

For more information circle **20** on inquiry card.

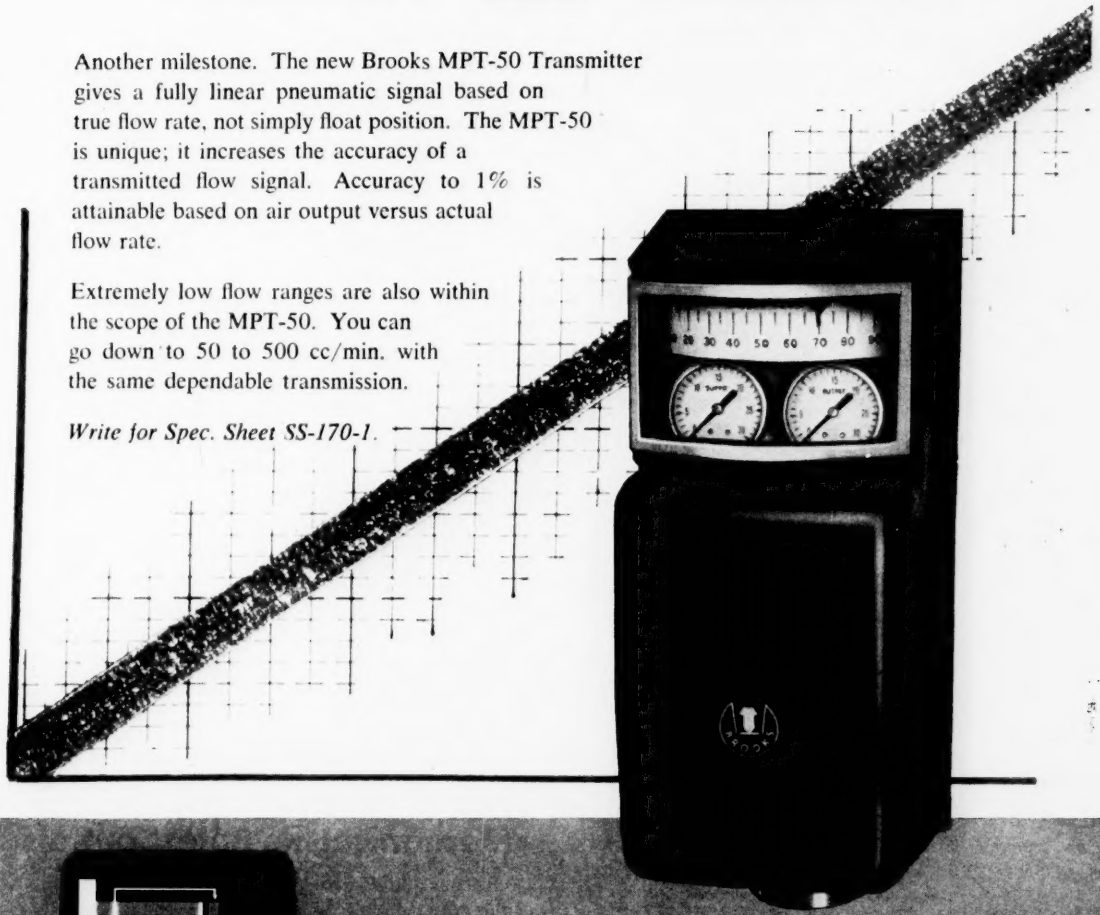
NEW... first truly linear

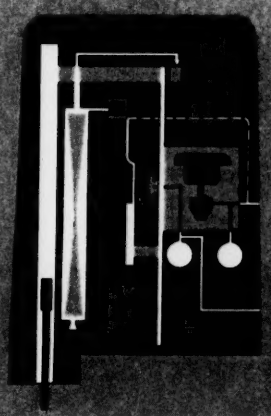
rotameter flow transmitter

Another milestone. The new Brooks MPT-50 Transmitter gives a fully linear pneumatic signal based on true flow rate, not simply float position. The MPT-50 is unique; it increases the accuracy of a transmitted flow signal. Accuracy to 1% is attainable based on air output versus actual flow rate.

Extremely low flow ranges are also within the scope of the MPT-50. You can go down to 50 to 500 cc/min. with the same dependable transmission.

Write for Spec. Sheet SS-170-1.





COMPLETELY NEW IN DESIGN CONCEPT

This magnetic rotary position converter has never been used in instrumentation before. It incorporates a magnetic lock that cannot break free. There is only one indicating position possible for a float position.

There's no back-loading of the built-in indicator or position converter from the pneumatic unit . . . operation is unimpaired. Vigorous, on-line testing has not shown any vibration effect.

The MPT-50 Transmitter is only 5 x 6 x 12 inches but full of proven new ideas. You should see it.

BROOKS ROTAMETER COMPANY

1058 I STREET
LANSDALE, PA.

Specialists in Complete Rotameter Instrumentation

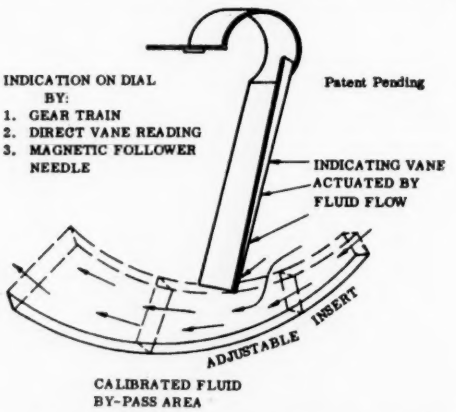
S.A. 1805

For more information circle **21** on inquiry card.

briefs

Movable-Vane Flowmeter

A portion of the flow (liquid or gas) acts upon a movable vane. As the vane rotates with increase in flow, the amount of flow by-passing the vane increases. An adjustable insert permits accurate calibration of each meter to meet operating requirements. This per-



mits relatively uniform increments on the scale for easy, accurate reading. A very small constant pressure drop across the meter provides sufficient power for operation . . . Flow pattern through the meter chamber keeps the housing clean. The movement of the vane combats accumulation of scale and sludge . . . The large area of vane engagement with the flow stream serves to average velocity differences and turbulence, providing an approximation of the ideal of laminar flow . . . (*From new 8-page Bulletin, V-100, Seico Instrument Div., Eclipse Fuel Engineering Co., Rockford, Ill.*)

For this literature circle **201** on inquiry card.

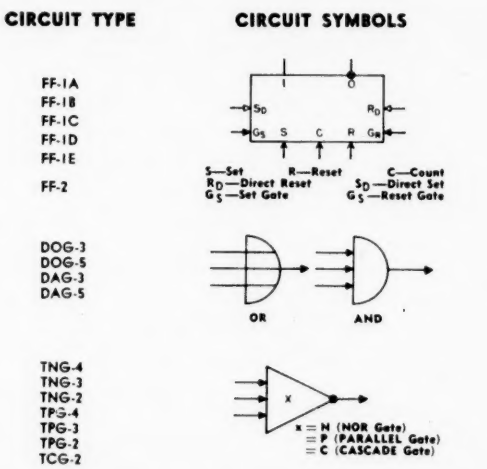
Sports Car "Rally" Computer

This precision rally computer simplifies rally navigation since all TSD (time, speed, distance) calculations are performed quickly and precisely . . . Kearfott's computer is independent of the car with the exception of electrical power required for the computer's motor. Since the computer operates only as required by the navigator for TSD computations, it cannot accumulate erroneous mileage or time in the event you go off course. . . . This computer is an "accumulative" type instrument which provides time data for any distance or distance data for any time . . . Continuously computes and displays time, speed, distance. It is possible to use continuous rally mileage information without the need for reducing continuous mileages to leg mileages . . . (*From new 2-page leaflet, Kearfott Co., Inc., Little Falls, N. J.*)

For this literature circle **202** on inquiry card.

Transistor Digital Circuits

The Epsco Series 100 Transistor Digital Circuits comprise a fully compatible set of all the basic circuit types required for digital equipment and system construction . . . transistor and diode logic circuits, amplifiers, signal forming circuits, time pulse generators, power supplies, visual indicators . . . The TDC 100

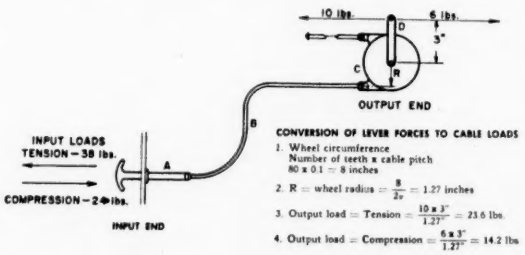


Series is intended primarily for central logic application . . . Contains specific types for all basic logic operations, using either transistor or diode gating, or a combination of both. All circuits are applicable to either non-synchronous or synchronous (clocked) logic using normal or "tail-end" gating . . . (*From new 20-page bulletin, Epsco, Inc., Components Div., 108 Cummington St., Boston 15, Mass.*)

For this literature circle **203** on inquiry card.

Mechanical Remote Controls

Assume the control . . . consisting of push-pull A, cable and conduit B, and control box C (80 tooth size) is installed to operate lever D mounted to the


10 lbs.
6 lbs.
3"
OUTPUT END
INPUT LOADS
TENSION—38 lbs.
COMPRESSION—24 lbs.
INPUT END
CONVERSION OF LEVER FORCES TO CABLE LOADS
1. Wheel circumference / Number of teeth x cable pitch / 80 x 0.1 = 8 inches
2. R = wheel radius = 8/2π = 1.27 inches
3. Output load = Tension = 10 x 3"/1.27" = 23.6 lbs.
4. Output load = Compression = 6 x 3"/1.27" = 14.2 lbs.

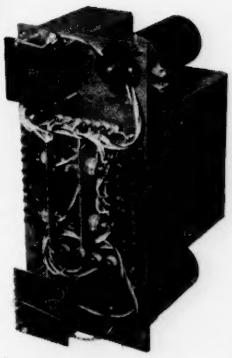
control box shaft. Assume forces resist the movement of the lever as indicated. Assume the handle loads necessary to overcome the lever forces and the friction of the control system are 38 lbs. in tension and 24 lbs. in compression . . . (*From 26-page spiral binder, including nomographs for estimating loads, Teleflex Inc., Church Rd., North Wales, Penna.*)

For this literature circle **204** on inquiry card.

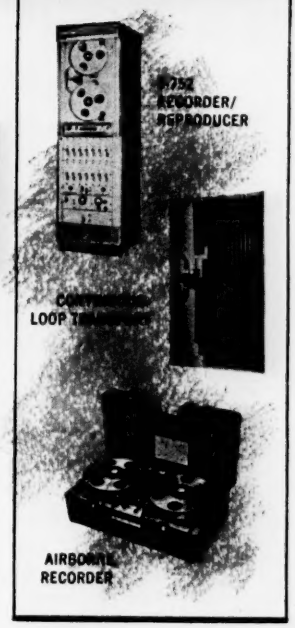
CEC announces the new digital magnetic tape recorder/reproducer

- *all transistorized electronics*
- *modular construction**
- *starts and stops in less than 5 milliseconds*
- *high-speed servo response*
- *continuous-duty servo motors*
- *all-metal-surface magnetic heads*
- *spacing between read and write heads*
- *uses ½" to 1¼" tape*
- *10½" reels with XARTB hubs*
- *designed for standard rack mounting*
- *5½ x 19" wide by 24½" high by 13" deep*

NOW AVAILABLE... Not merely a laboratory instrument, but a fully ruggedized, reliable digital recorder designed for a whole gamut of industrial applications where long periods of unattended operation with minimum maintenance and down-time are paramount. Standardized speeds, track-width and spacing, and start and stop distances assure complete compatibility with other digital tape transports and handlers. *Contact your nearby CEC field office for complete information,* or write for Bulletin CEC 1608-X14.



**Modularized components, such as Power Supply Unit at right, permit instant access and easy maintenance or replacement with minimum down-time.*



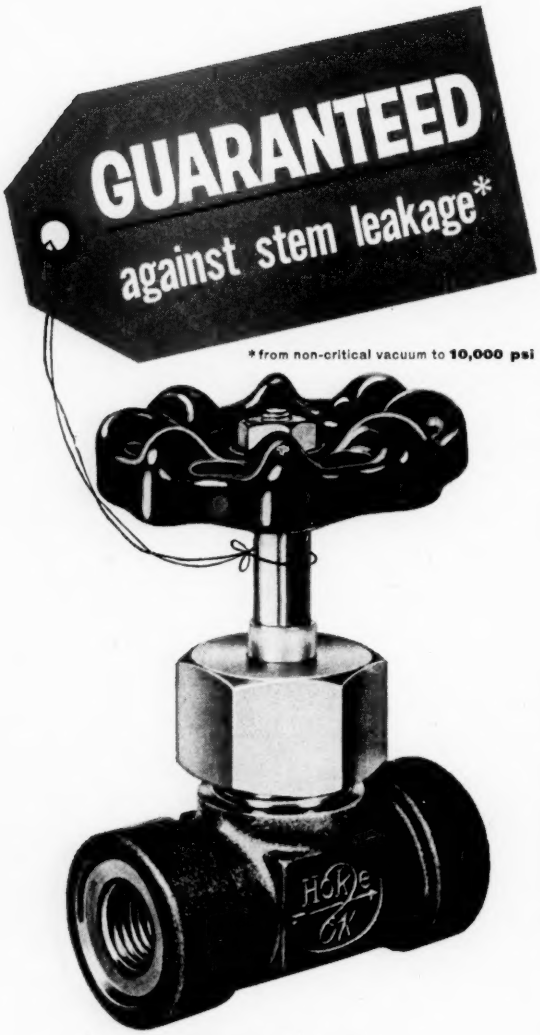
DataTape Division

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **22** on inquiry card.



SERIES 100
FORGED NEEDLE VALVES

Hoke presents the Series 100—a new line of full-flow, general purpose valves especially designed for water-oil-gas application and *guaranteed* against stem leakage from non-critical vacuum to 10,000 psi! Here you'll find traditional Hoke quality combined with such unusual features as the exclusive Hoke nylon stem wiper. Offered at a truly competitive price.

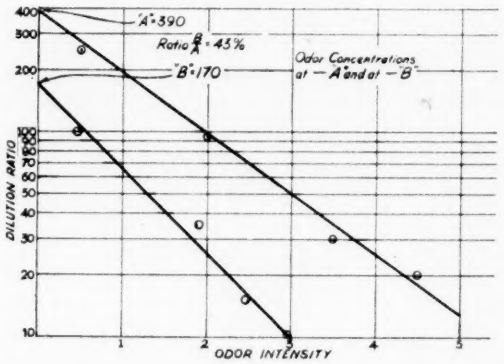
HOKE

SEE NEXT PAGE FOR INSIDE STORY ON THIS VERSATILE NEW VALVE!

For more information circle **23** on inquiry card.

Odor-Meter

The Odor-Meter . . . employs two dilution stages with controls permitting the production of any odor concentration in proportions ranging from 1/20 to 1/40,000 of those in the original stream. The resulting mixture, conditioned when required, is delivered through tubing to helmets worn by human subjects . . . It is not generally appreciated that subjective

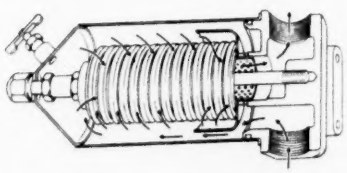


odor measurements . . . can result in figures describing odor quantity and odor concentration that can be employed in evaluation problems and in engineering design. Such figures are just as tangible as those employed in describing dust quantities (grains per cubic foot, pounds per hour, etc.) or those for describing vapors and gases (parts per million, cubic meters per hour, etc.). They can be employed in micrometeorological calculations for rate of dilution, for determination of the efficiency of scrubbers or other odor-removal units, for rating the relative importance of various odor sources, and for other similar engineering purposes . . . (*From new 4-page bulletin, Hemeon Associates, 121 Meyran Ave, Pittsburgh 13, Pa.*)

For this literature circle **205** on inquiry card.

Instrument Air

Certain processes and instruments require relatively small quantities of extremely clean compressed air. Dirt particles or entrained liquids in this air impair operation, affect accuracy, and shorten instrument life.



The Air-Maze instrument air filters employing special felt type filter media are designed to remove fine dirt particles and entrained liquid droplets from a compressed air stream . . . The filter element is made up of two diameters of felt discs alternately stacked on a perforated center tube to provide increased filter area. (*From new 2-page release form IAF-1256, Air-Maze Corp., 25000 Miles Rd., Cleveland 28, Ohio.*)

For this literature circle **206** on inquiry card.

Teflon

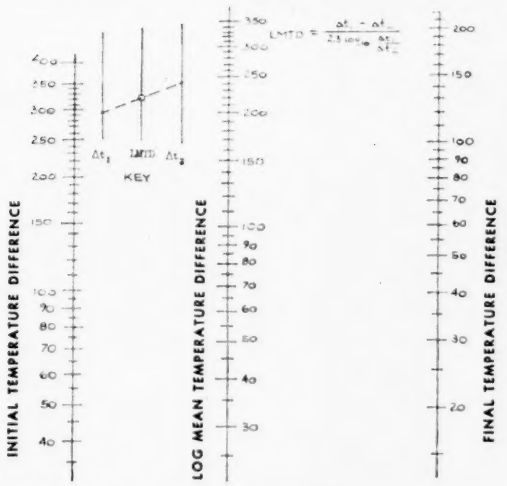
Teflon is a basically different engineering material . . . The chemical, electrical and mechanical properties of virgin material offer engineering advancements possible with no other component material. The use of fillers to enhance specific properties offers ever further improvements. It has been demonstrated frequently that mere duplication of the design and dimensions of rubber, leather, ceramic, phenolic, metals and composite materials for which Teflon is advantageously substituted, fails to bring out the full improvement this new material can offer . . . Halogen specializes in the economical production of final parts from basic forms such as rod, tubing, extrusions, preform moldings, etc., which they also manufacture. . . *(From new 4-page bulletin, Halogan Insulator & Seal Corp., 10121 Franklin Ave., Franklin Park, Ill.)*

For this literature circle **207** on inquiry card.

Chart For Logarithmic Mean Temperature Difference

The most disliked formula—disliked even by engineers because of the time required to use it—is the one given on the accompanying chart for determining the Logarithmic Mean Temperature Difference.

It is easier to find the "average temperature difference", and, even though the result is incorrect, the



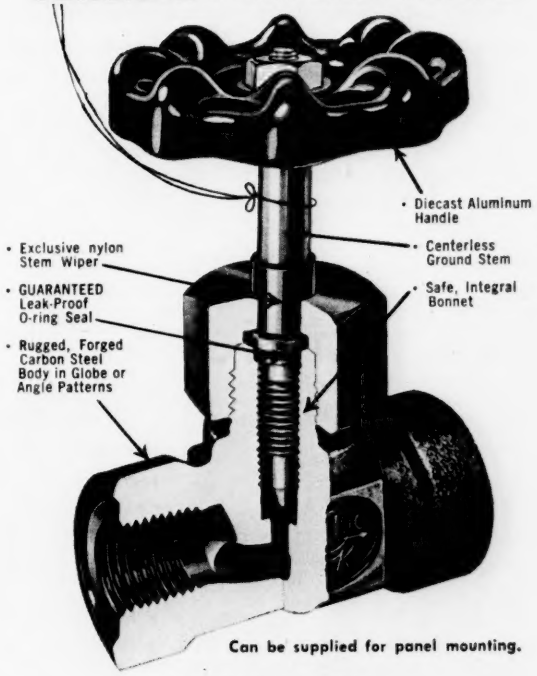
"easy method" is often used. It should *never* be used on important work. The accompanying chart was therefore developed and it makes the work even easier than the incorrect "easy method" . . .

Between the left hand and middle columns you will see the Key, which shows how to use the chart. Connect the Initial Temperature Difference with the Final Temperature Difference as indicated by the dotted line. The intersection of that connecting line with the middle column gives the LMTD almost instantly. And, of greatest importance—the answer is correct . . . *(From new 8½" x 11" free chart, Dean Thermo-Panel Coil Div., 616 Franklin Ave., Brooklyn 38, N. Y.)*

For this literature circle **208** on inquiry card.

THE INSIDE STORY*

*ON HOKE'S VERSATILE, NEW GENERAL PURPOSE VALVE


• Diecast Aluminum Handle
• Centerless Ground Stem
• Safe, Integral Bonnet
• Exclusive nylon Stem Wiper
• GUARANTEED Leak-Proof O-ring Seal
• Rugged, Forged Carbon Steel Body in Globe or Angle Patterns

Can be supplied for panel mounting.

SERIES 100
FORGED NEEDLE VALVES

Use these versatile, full-flow Series 100 valves for throttling, regulating, or shut-off. Use them for applications where temperatures range as low as -40° or as high as 200° F. They're compact in size and available in a selection of male and female connections. *Guaranteed* against stem leakage!

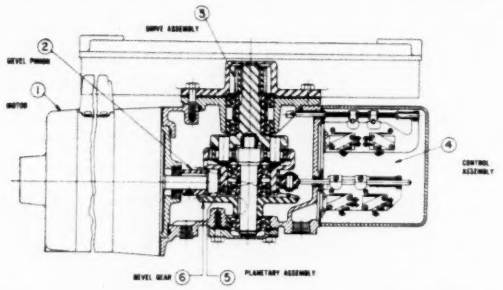
Write for complete information and FREE sample valve on your company letterhead.

HOKE
HOKE INCORPORATED
Fluid Control Specialists
31 PIERMONT ROAD, CRESSKILL, N. J.

For more information circle **24** on inquiry card.

Valvmatic Actuator

Valvmatic is ideal to open and close remote units as well as to actuate valves . . . Unusually fast, easy installation . . . Valve remains in line; piping is left undisturbed. No machining of special valve nuts. Position and torque limits provided for both rotation



directions to prevent valve injury . . . Adaptable to nearly every application where valve handle does not rise, and where valve handle can rotate when valve is operating under power. Remote push-button operation; in the event of power failure, just pull two pins to operate valve manually . . . High-torque, instantly-reversible, totally enclosed motor . . . (*From new 4-page Catalog, V-200, C. H. Wheeler Mfg. Co., 19th and Lehigh Ave., Phila. 32, Pa.*)

For this literature circle **209** on inquiry card.

Automatic Analytical Chemistry

The Autoanalyzer is a system for automatic analytical chemistry. It approaches the problem in a dramatically new way. Conventional manual technics are predicated on (1) measuring out specific volumes of fluids, (2) creating a change in the fluid, (3) measuring the change and finally, (4) relating that change to the volume for a specific value. To arrive at a result every reaction must generally be brought to completion.

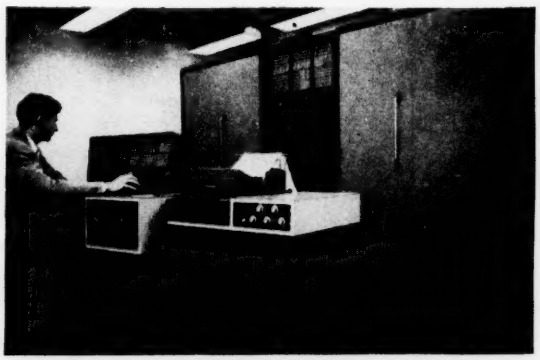
None of these progressive steps are necessary with the Autoanalyzer. On the contrary, it continuously measures and compares on a moving graph, the level of concentration of a given component in the test solution against a known concentration of that component in a standard control solution . . . Once the experiment has been set up (which involves only hooking up a set of tubes and takes less than a minute) the samples to be analyzed are picked up, pumped along and mixed with a flowing stream of diluent. The diluted sample then moves through a dialyzer where its diffusable constituents are separated and fed into a flowing reagent stream. This stream may now be passed through . . . a colorimeter, a conductance bridge, a flame spectrometer, or a temperature-sensing element for analysis. (*From new 16-page brochure "AutoAnalyzer," Technicon Instrument Corp., Chauncey, New York.*)

For this literature circle **210** on inquiry card.

save time and money... ship via

"DATATRONS" CROSS U.S. IN NORTH AMERICAN VANS

High-speed electronic computers made by Electro-Data Division, Burroughs Corp., travel door to door uncrated in smooth-riding North American vans. Left, unit being loaded at Pasadena plant. Right, "Datatron" ready to go to work. (North American recently moved entire Electro-Data Division to new 40,000 sq. ft. plant in California — another widely used industrial service offered by the world's leading van line!)



"America on the go" Hear Alex Drier's Salutes to Industry—Every Sunday Evening, 6:05 P.M. New York Time, NBC-Monitor

DOOR-TO-DOOR DELIVERY . . . UNCRATED . . . HIGH-VALUE PRODUCTS . . . EXHIBIT DISPLAYS

For more information circle **25** on inquiry card.

Flag Type Circuit Indicators

Emico Flag Indicators are miniature instruments for indicating electrical circuit conditions by the semaphore system. A change in circuit current flowing through the instrument coils causes a magnetically operated semaphore arm to pass in view of a window masking a white background color with the red color of the arm. The effect of this action makes visible through the window a complete transition of color, such as red when the current is off, and white when the current is on, or vice versa . . . (*From new 5-page bulletin, Electro Mechanical Inst. Co., Perkasie, Penna.*)

For this literature circle **211** on inquiry card.

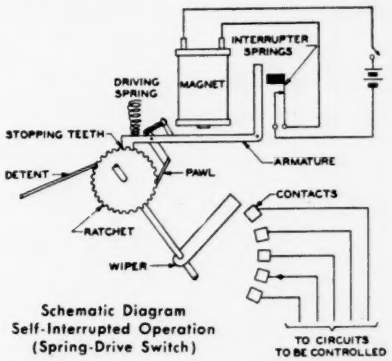
Micro-Rule

Micro-Rule is a rule to measure minute distance. Working on an entirely new principle, it provides a means to readily measure and lay out distances to 1/1000 of an inch without eyestrain and without the use of a glass. The graduation lines on the scale end in "V" shaped notches and with the aid of a pricker the distances are transferred to the paper, or other medium, as fine dots . . . can be used for laying-off angles . . . can be used in place of a proportional divider . . . can be used when drawing circles, especially when diameters are in decimals . . . (*From new 38-page catalog, Theo. Alteneder & Sons, 1217 Spring Garden St., Phila. 23, Pa.*)

For this literature circle **212** on inquiry card.

Rotary Stepping Switches

The high-speed, multi-contact rotary stepping switches are widely used to perform four types of control operations: (1) Selecting any one circuit from among a number. (2) Selecting an idle circuit from a group. (3) Consecutively performing operations in



Schematic Diagram
Self-Interrupted Operation
(Spring-Drive Switch)

separate individual circuits. (4) Providing times pulses at accurately spaced, equal or unequal, time intervals . . . Under proper conditions, and with self-interrupted operation, Automatic Electric stepping switches will operate at speeds up to 60 steps per second or more! Thus, they are used for control systems in which intervals of time are of critical importance . . . (*From new 102-page catalog, Automatic Electric Co., Northlake, Ill.*)

For this literature circle **213** on inquiry card.

North American Van – UNCRATED!

DOUBLE-CHECK THESE ADVANTAGES:

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- **Saves disassembly and reassembly time.**
- **Door-to-door delivery; no drayage cost.**
- **Proved gentlest in Impact-O-Graph tests.***
- **Prompt pickup, fastest service anywhere.**

*Impact-O-Graphs placed with products shipped via North American van showed far less shock and jar than other methods of transportation. Coupon brings report of findings.

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Phone your local North American Van Lines Agent now . . .

He's listed in the Yellow Pages under "Movers." Or send coupon below for details of High-Value Products and other North American specialized industrial services, and "Wife-Approved" moves for transferred personnel. North American Van Lines, Inc., World Headquarters, Fort Wayne, Ind., North American Van Lines Canada, Ltd., Pickering, Ont.

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For more information circle **25** on inquiry card.

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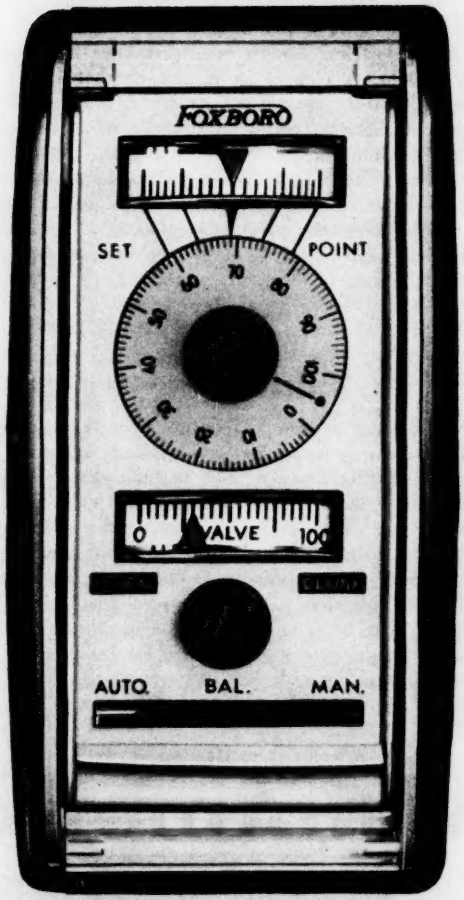
...for flow, pressure, and level

Low Displacement Force-Balance Transmitters
...for flow, pressure, and level

Thermocouple and Resistance Bulb Converters
...magnetic amplifiers...no vibrators
...no mechanical rebalancing

Displacer Level Transmitters
...force-balance for simplicity

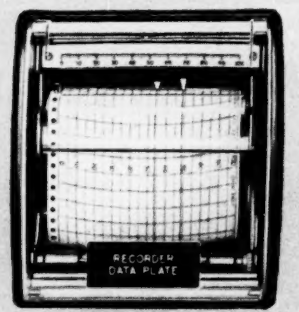
Control Valves
...electro-pneumatic and electro-hydraulic actuators



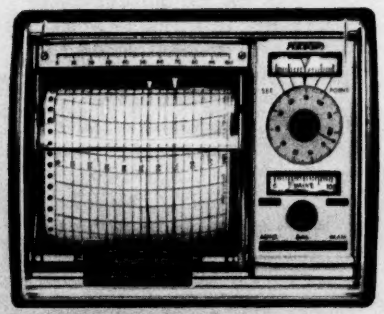
CONTROLLER
The Electronic Consotrol Controller (shown 4/5 actual size) concentrates all control and supervisory functions in one slim 3 x 6 inch case. Controller operation is entirely independent of recorder.

FOXBORO Electronic

REG. U.S. PAT. OFF.



RECORDER
Electronic Consotrol Recorders (shown ¼ actual size) use a simple, powerful pen motor which can be operated directly from transmitter signal without amplification. Available in 1 and 2 pen models.



COMBINED RECORDER-CONTROLLER
Electronic Consotrol housing design permits unequalled flexibility in panel arrangement. Recorders and controllers can be mounted separately in individual housings—or enclosed in a compound unit. Regardless of mounting, either unit pulls out independently.

For more information circle **26** on inquiry card.

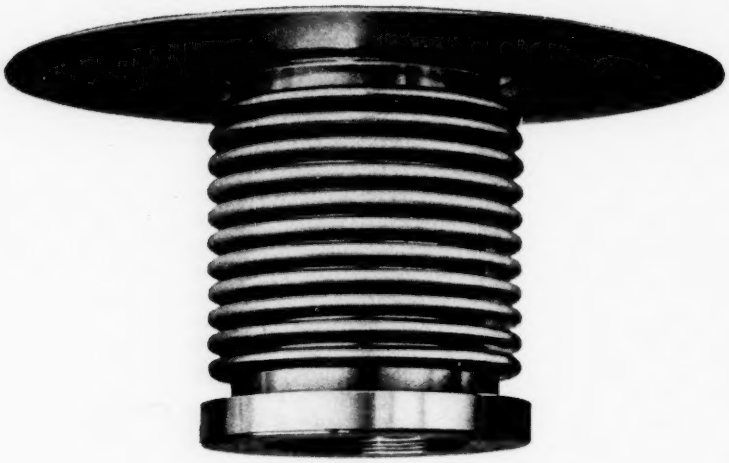
for the first time... the 100% solid state electronic system!

- thermocouple and resistance bulb converters – using magnetic amplifiers
- choice of force-balance and motion-balance transmitters
- long time-constant tubeless controllers

Consotrol Instrumentation

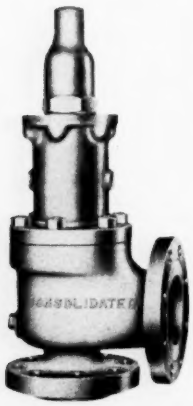
Electronic Consotrol* Instrumentation—the most complete and advanced family of electronic-operated measurement and control instruments available today! That just begins to describe Foxboro's dramatic new advance in instrumentation. ✓ ✓ ✓ Foxboro electronic transmitters, indicators, recorders, control stations, computing stations, valve actuators and other final operators cover every function in the control loop. All are linked by a d.c. current signal. All are completely tubeless. Even thermocouple and resistance-type systems no longer require vacuum tubes. ✓ ✓ ✓ Electronic Consotrol systems convert temperature, pressure, flow, level measurement, etc., to a proportional signal **at the transmitter.** Transmission to a remote control station is instantaneous—using an electronic motion-balance or force-balance transmitter. Designs are available for both hazardous and non-hazardous areas. ✓ ✓ ✓ Electronic Consotrol Instrumentation heralds a whole new era in process control engineering. Write Foxboro today for the new 32-page Catalog 21-10 which gives full details. The Foxboro Company, 4610 Neponset Ave., Foxboro, Mass., U.S.A. *Reg. U.S. Pat. Off.

For more information circle **26** on inquiry card.



CORRUGATED SLEEVE

shields working parts



Consolidated Safety Relief Valve with Sealing Bellows. Type 1900-30 Series, Sizes: 1½" x 2" to 8" x 10".

A durable, two-ply stainless steel Sealing Bellows in Consolidated Safety Relief Valves isolates contaminants, corrosion or viscous fluids from the working parts. The Bellows is balanced with the seating surface. Capacity is less affected by variable back pressure, so you can use smaller discharge piping and reduce the cost of pressure-relieving systems.

Full-rated relieving capacity is certain at all positions of the single blowdown adjusting ring because a fixed maximum secondary orifice provides full lift at 10% overpressure. Even with superimposed back pressure in the relieving system, valve action is consistently positive.

Protection of working parts is but one of many reasons why Bellows Type Consolidated Safety Relief Valves assure absolute protection for personnel and facilities. Write for details, including facts about the Standard valve that you can convert to the Bellows type in your own shop. Ask for Catalog 1900.

MANNING MAXWELL & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Tulsa, Oklahoma
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Circle **28** on inquiry card. ⟶

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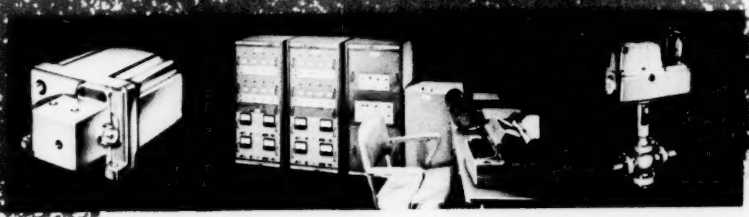

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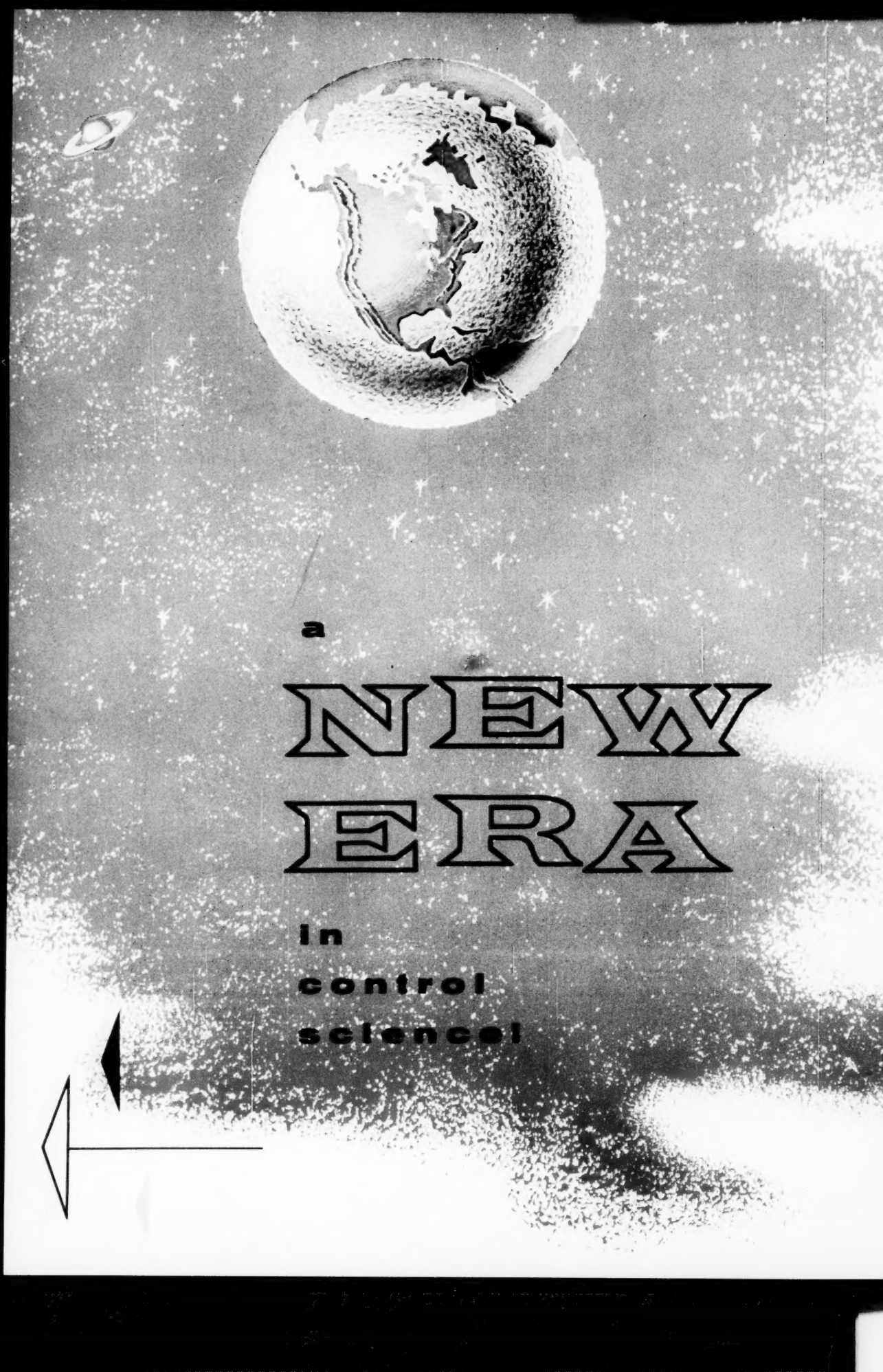
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Research and Development is the only short cut to faster, better, more economical production.

The R & D facilities of Lindly & Company have earned international renown in the fields of photo-electric, infrared, optical, electro-mechanical and electronic techniques. More than a score of Lindly-developed devices and systems have been developed for industrial and military applications. Many more are on the way.

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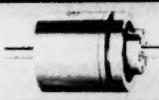
Compact – Quiet – Swift

Simplatrol

FIXED FIELD ELECTRIC CLUTCHES

Electric Clutch

Coupling Brake



Clutch Coupling

Three styles from 7/8" to 3 1/8". Torque output from 10 oz. inches to 100 lb. inches.

In Miniature & Small Sizes

Introduced only a few short months ago, Simplatrol Fixed Field Electric Clutches have found popular application wherever space is tight, noise is objectionable and performance requirements are rigid.

PATENTED DIAPHRAGM ACTION Makes the Difference

No other electric clutch and brake can duplicate the patented Simplatrol diaphragm . . . the *only* moving part in Simplatrol Fixed Field Clutches. Here is a proved advantage . . . offering an absolute minimum of maintenance.

Ask for Simplatrol Fixed Field Literature

Simplatrol products corp.

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NOW...

PRE-PRINTED PHOTO CHARTS

Did you know that the manufacturer of almost any standard photo-recording oscillograph can supply you with photo-sensitive recording charts *already printed with amplitude and reference lines?*

He can do this because of a new, exclusive process developed by the Bristol special chart service for printing to accuracies of ± 0.005 inch through photo-sensitive emulsions.

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This outstanding new development is just one of the special charts you can get from Bristol. Our chart-printing facilities can handle strip charts up to 29 5/8 inches across and circular charts up to 12 inches diameter.

Some of the available papers include: highest quality regular chart paper in standard thicknesses; wax-coated, heat-sensitive, chemically-coated, electrically-sensitive or pressure-sensitive papers; papers for metallic marking; foil-type laminates for extreme dimensional stability; card stock; carbon coated (or smoked) papers. Also special punchings or printing to any mathematical law.

Write for complete data on the Bristol special chart printing service. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn.

B-16

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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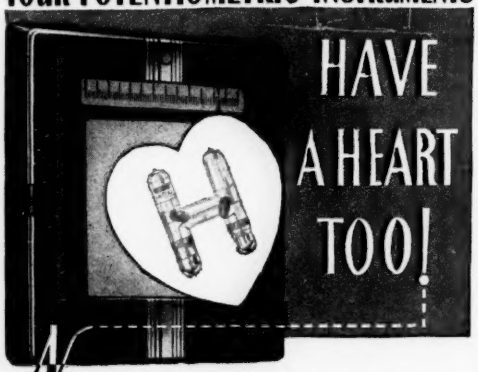
← Circle **28** on inquiry card.

YOUR POTENTIOMETRIC INSTRUMENTS HAVE A HEART TOO!



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

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EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

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Compact, rugged • 600 line resolution • Clear pictures at 10 ft. candles or less • Electronically controlled automatic light compensation

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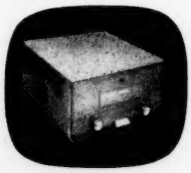
Camera and control may be located up to 500 feet apart • Electronically regulated power supply



Monitors
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INLET
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ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

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No valves, pistons, or vanes.
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Original performance constant over a long pump life.
Low maintenance cost.

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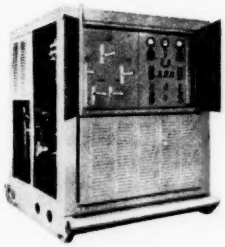
When the target is space and a million dollars' worth of missile rests idly on the ground—not even a long countdown helps. In a showdown situation, the successful shoot depends on the "go, no-go" type of test that pinpoints the trouble.

NEXT TIME...LOOK TO INET FOR PRECISE GROUND POWER



This INET 400-cycle ground power unit was tailor-made for the Atlas. In meeting all of Convair's specifications for pre-flight calibration of electrical systems, the unit operates in parallel with the missile's power system and provides remote control regulation. Frequency regulation is ±0.2%. With shock load equal to a third of rated output, frequency recovers to ±0.2% in 0.15 seconds. Voltage regulation is ±0.5% with recovery time at 0.30 seconds.

Missile men desiring a special reprint of the above cartoon should write to "Count-down", c/o Inet Division of Leach.

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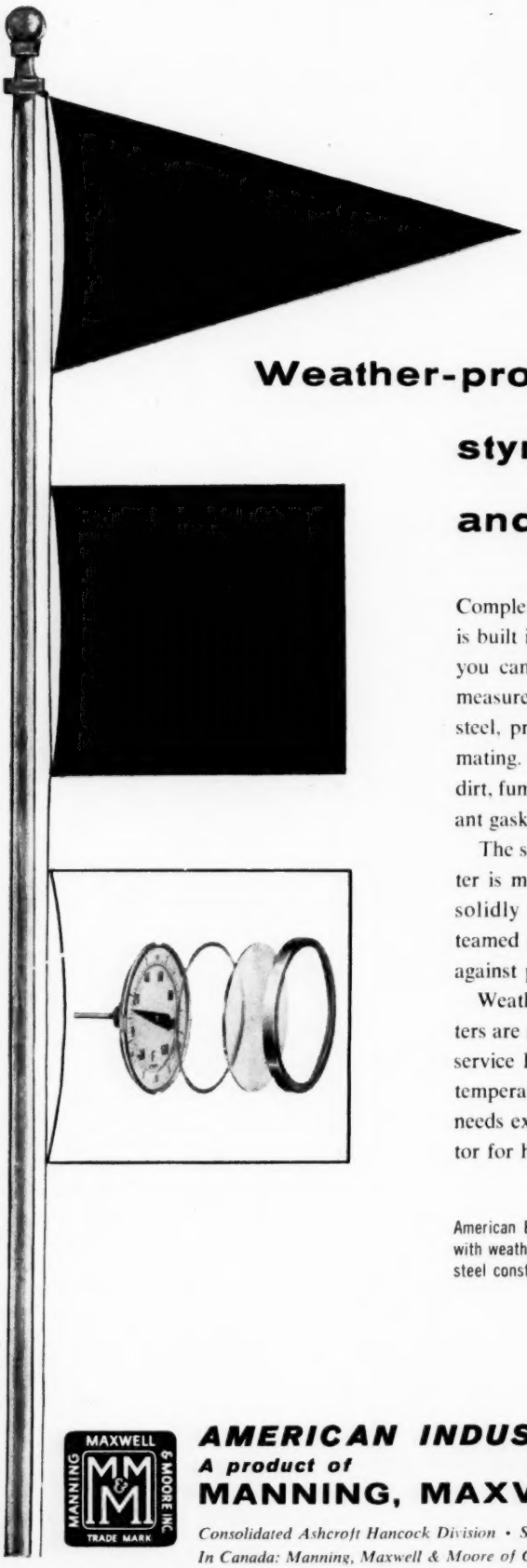

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American Bi-Metal Thermometer with weather-proof stainless steel construction.

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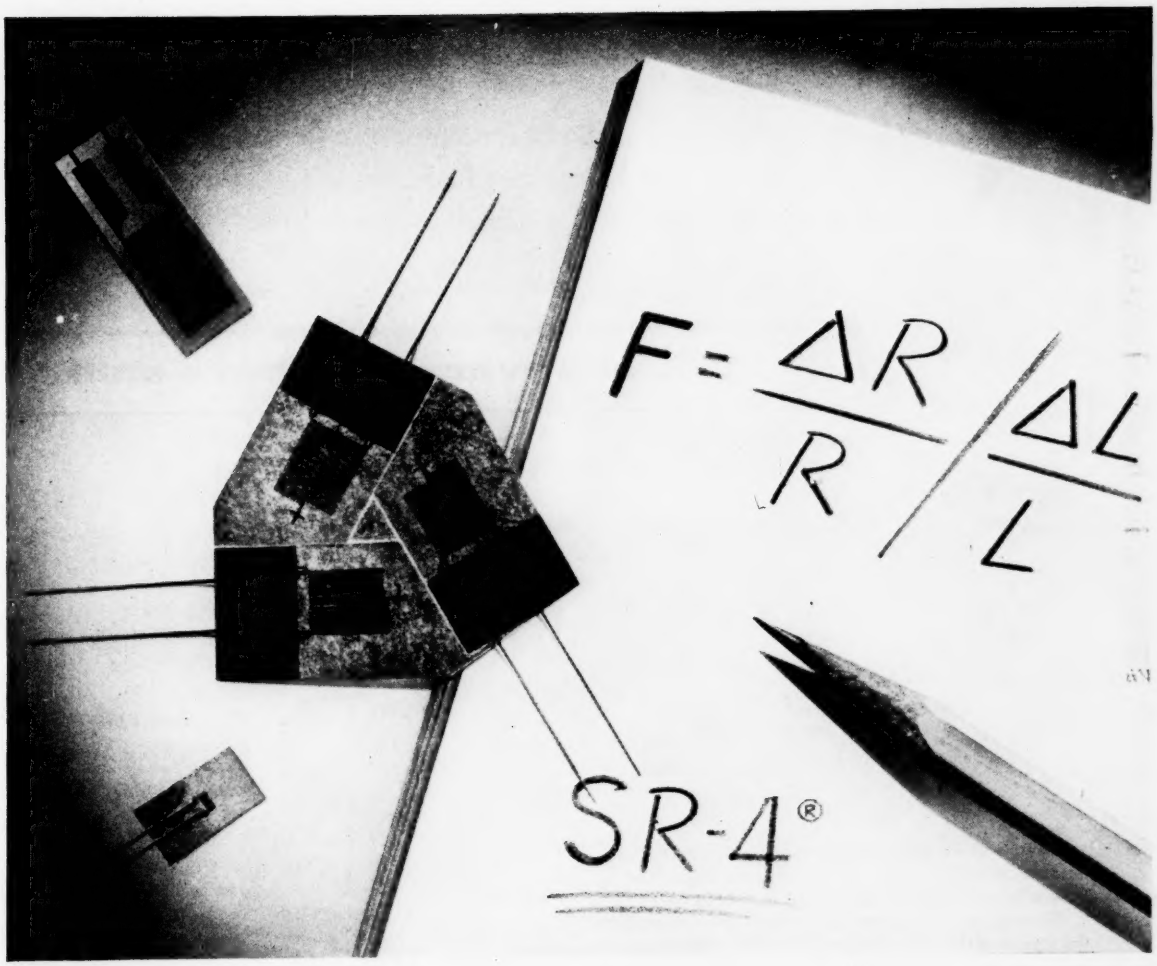

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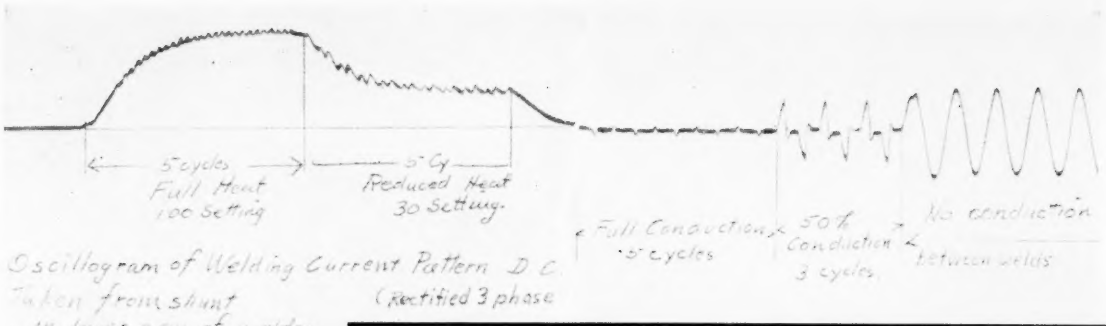
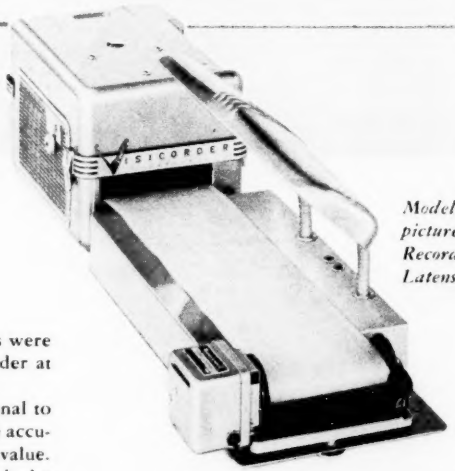


this is a record of phase shift

Shows gradual build-up and decline of welding current.
Essential in making good spot welds

Oscillogram taken across ignitron tubes.

Visicorder Record — ⅓ actual size



Model 906A Visicorder pictured with Record Takeup and Latensifier Unit.

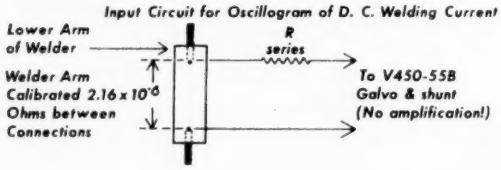
These welder phase-shift heat-control patterns were directly recorded with a Honeywell 906 Visicorder at Bristol Aircraft (Western) Limited in Winnipeg.

Since the welding heat generated is proportional to the square of the current value, phase shift must be accurately controlled in order to determine the heat value. If the phase shift dial is not accurately calibrated, the result is too much or too little heat, and a poor weld.

In this application, the Visicorder is an essential guide to accurate calibration, since ink-type recorders do not cover the sensitivities and frequencies needed and an oscilloscope would present a continually changing pattern since most recording periods are less than 10 cycles. The directly-recorded Visicorder patterns allow a convenient study of the exact time when the current wave form was being cut off.

Here is the circuit used in this test.

Input Circuit for Oscillogram of D. C. Welding Current



The Honeywell Visicorder is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new Accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Honeywell

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Reference Data: Write for Visicorder Bulletin

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revolutionary pressure reducing valve with mechanical pilot out of steam path

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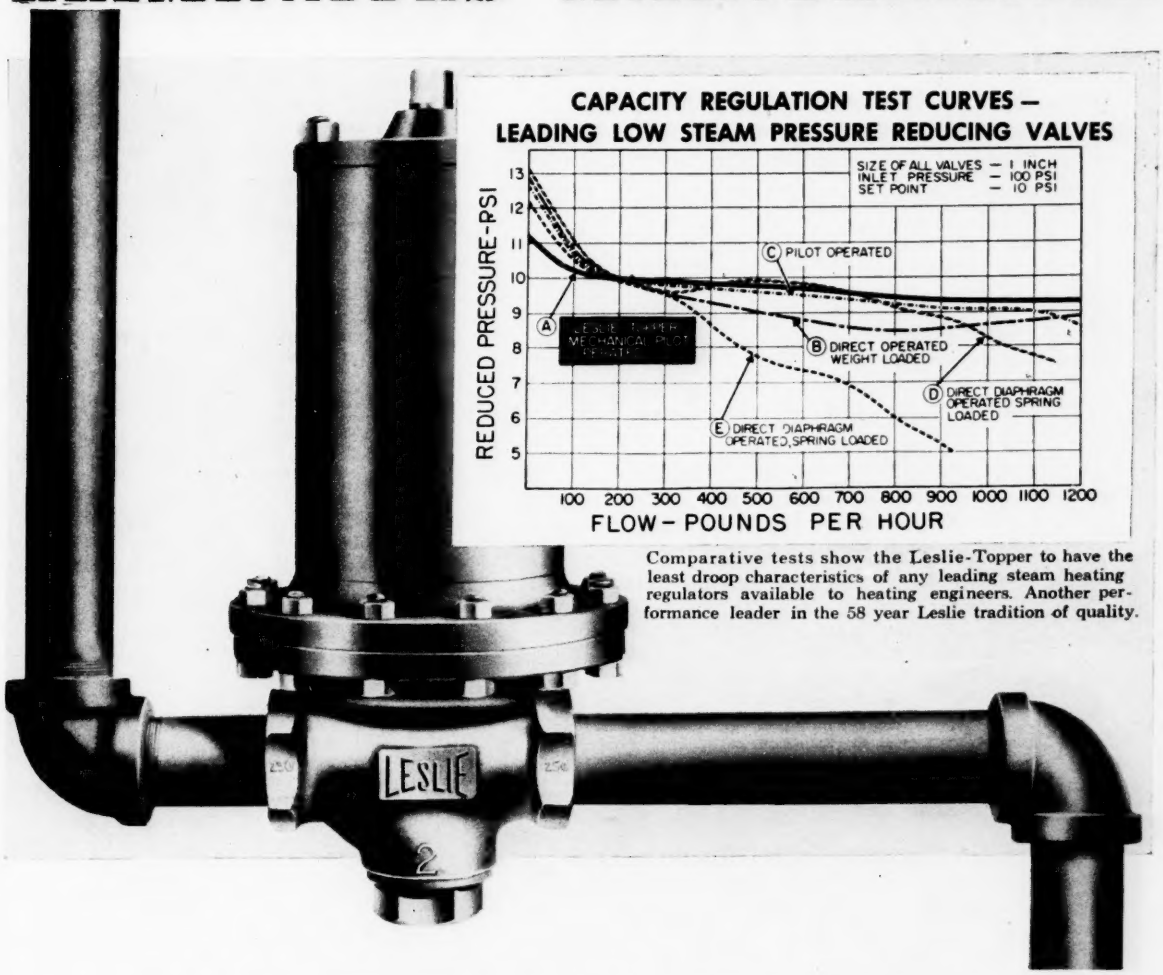

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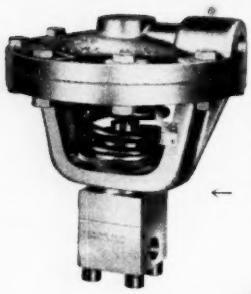

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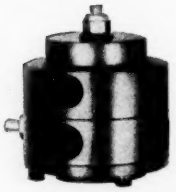
Throttling "Bantam" Diaphram Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500°F, characterized, renewable trim, 316 stainless steel and *Teflon* only wetted surfaces, low in hysteresis size and weight, 2000 series "Bantam" Control Valves available for on-off service.



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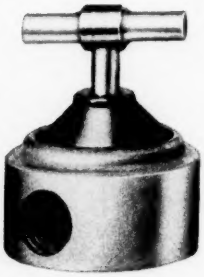

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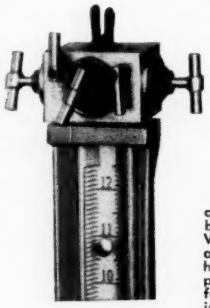

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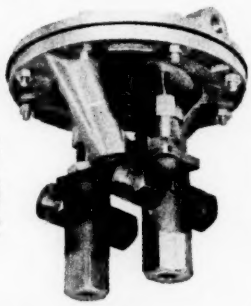

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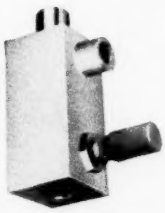
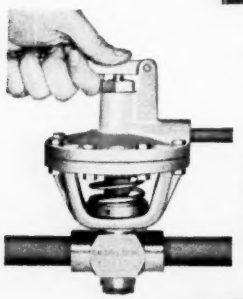
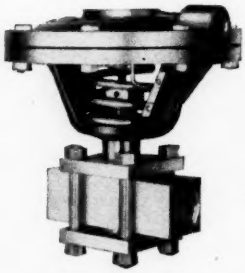




MANUAL RESET

Wherever control air on dangerout or toxic process flows must be blocked for safety, on air failure until manually reset, these valves insure against disaster. Standard sizes ¼" and ½" I.P.S.

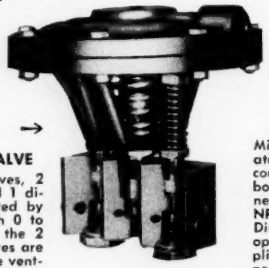


AIR OPERATED CONTROL VALVE

Miniature diaphragm operated control valve. Barstock construction with bolted bonnet and blindhead. Connections from ¼" to 1" NPT. Cv. from .001 to 10.0. Direct or reverse acting operators for control applications. Extension bonnets for extreme temperatures available.

THROTTLING CONTROL VALVES WITH TOP MOUNTED MOORE POSITIONER

Compact, accurate and rugged. Light weight. Sizes from ¼" to 1" NPT. Flanged connections available. Barstock bolted bonnet, blindhead and body. Cv. from .001 to 10.0 with pressures to 1000 PSI.



BLOCK VENT VALVE

3 balanced valves, 2 reverse acting and 1 direct acting, actuated by one operator. With 0 to 3 psi control air, the 2 reverse acting valves are closed, center valve vented. At 6 psi control air, all valves closed. At 12 to 15 psi, the 2 reverse acting valves are open and the vent valve is closed, allowing free flow through body. Design pressure 1000 psi. *Teflon*, Chevron packing. *Teflon* seating for tight shut off.

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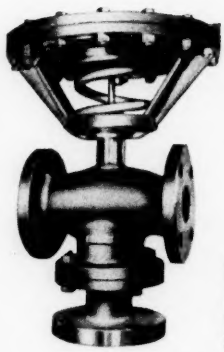
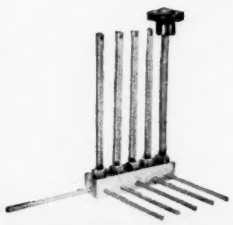
Aluminum diaphragm operator, stainless steel body and trim, *Teflon* packing with *Teflon* seating for tight shut off. Available up to 2", flanged or screwed.





MINIMUM VOLUME MANIFOLD

A compact manifold consisting of five packless valves having .0006 cubic inches volumetric displacement. Can be cam actuated for programming applications. Soldered, welded, tubing or NPT connections with applicable materials of manufacture for high temperature and high pressure service.

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For more information circle **41** on inquiry card.

BOOK Reviews

Logical Design of Digital Computers, by Montgomery Phister, Jr. [c1958.] John Wiley & Sons, New York 16, N.Y. 408p. $10.50 9¼ in. Describes *techniques* rather than the computers themselves. Using synchronous circuit components almost entirely, the author interprets the methods and techniques of various workers in this field, and applies them to a wide variety of problems in the design of computers. Provides the information necessary for complete design of general or special-purpose computers.

Automatisme Régulation Automatique Servoméchanismes, by V. Broida. Dunod. Paris, France. [1957.] 308 p. 6½" x 9¾". French book for readers out of school for many years, interested in the exact mathematical and logical background but essentially unable to handle higher math, and those who are not electronic experts. Frequency response is explained starting from transient response (and not vice versa) in an effort to convey better understanding of servomechanisms.

Feedback Control Systems, by Otto J. M. Smith. [1958.] McGraw-Hill Book Co., New York 36, N. Y. 694 p. $13.50. 6" x 9". Presents a unified philosophy for the analysis and design of feedback systems. Intended for first year of graduate study as textbook for readers with a previous course in control systems or feedback systems.

Transistor Manual, Ed. 3. [c1958.] General Electric Co., Semi-conductor Products, Syracuse, N. Y., 168 p. 5½" x 8½", paperbound $1. Almost three times size of first edition. 104-page application portion contains info from simple radio to non-saturated flip-flop circuits. Also treated are tetrode transistors, unijunction transistors, and controlled rectifiers and their functions.

Principles of Electrical Measurements, by H. Buckingham and E. M. Price [1957.] Philosophical Library, New York 16, N. Y. 600 p. $15. 8¾". British book intended for both the advanced student and the professional engineer. Methods of measurement are grouped according to the principles involved.

Tracer Applications for the Study of Organic Reactors, by John G. Burr, Jr. 1957. Interscience Publishers, New York 1, N. Y. 291p. $7.50. 9¼ in. Attempts to relate the examples of the use of isotopes to the principles of chemical research, and to indicate what types of problems can be best handled by tracer techniques. Applications are arranged according to reaction classifications most familiar to the organic chemist.

Handbook of Calculus, Difference and Differential Equations, by Edward J. Cogan and Robert Z. Norman. Prentice-Hall, Inc., Englewood Cliffs, N. J. [1958.] 263 p + XII. $6. Has excellent diagrams and print and contains large table section of natural trigonometric functions, common logs of numbers and trigonometric functions, also exponential and hyperbolic functions. Intended as supplement to a textbook, it features tables for the solution of differential equations.

How to Read Schematic Diagrams, by David Mark. [c1957.] John F. Rider, New York 11, N. Y. 147 p., unbound. $3.50. 8½ in. Intended to teach the untrained reader to *interpret* symbols and notations in pictorial and schematic electrical and electronic diagrams.

calibrated AC/DC signal source

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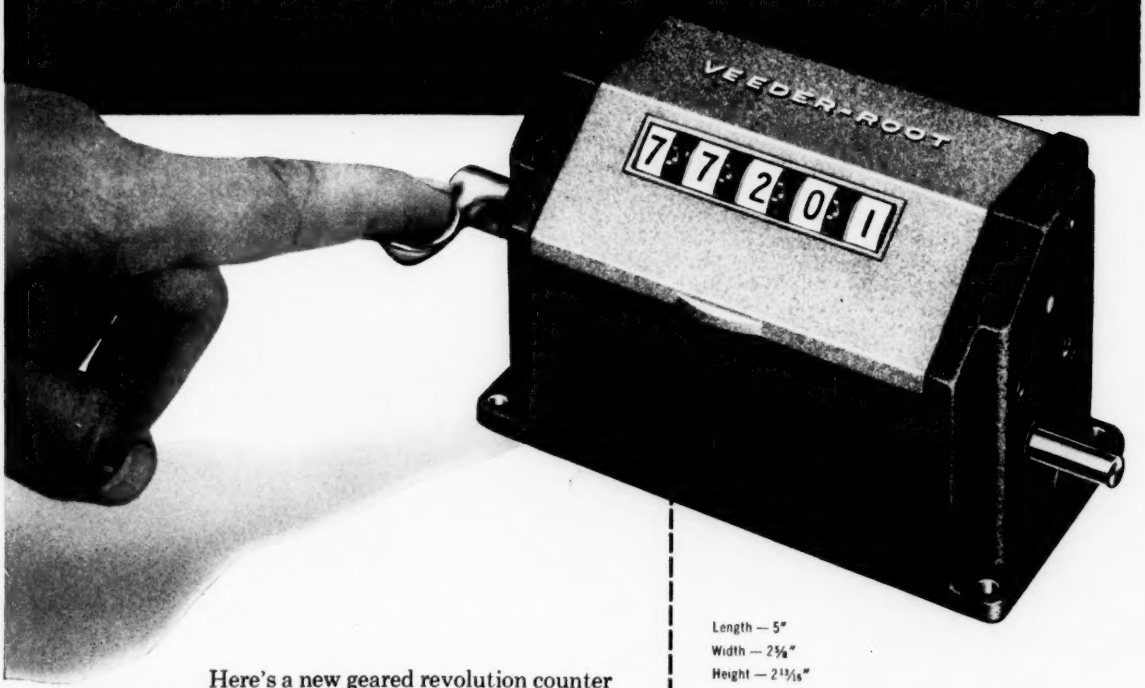
Still More News from VEEDER-ROOT

NEW *Quick-Reset, High Speed* *Geared* REVOLUTION COUNTER



Length — 5"
Width — 2⅝"
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Here's a new geared revolution counter designed for general purpose work where high speed and quick reset geared revolution counters are required. It will accept speeds up to 6000 rpm or 8000 cpm.

One flick of the lever (through 60° arc) will reset the counter to all zeros. A new modern case design and extra big numbers (.227 in. high) provide excellent visibility at extremely wide angles. The counter is ideal for in-line reading.

Where dependability is desired together with the added feature of positive subtraction, the new Model 1523 revolution counter offers exceptional possibilities. Write now for prices and specifications.

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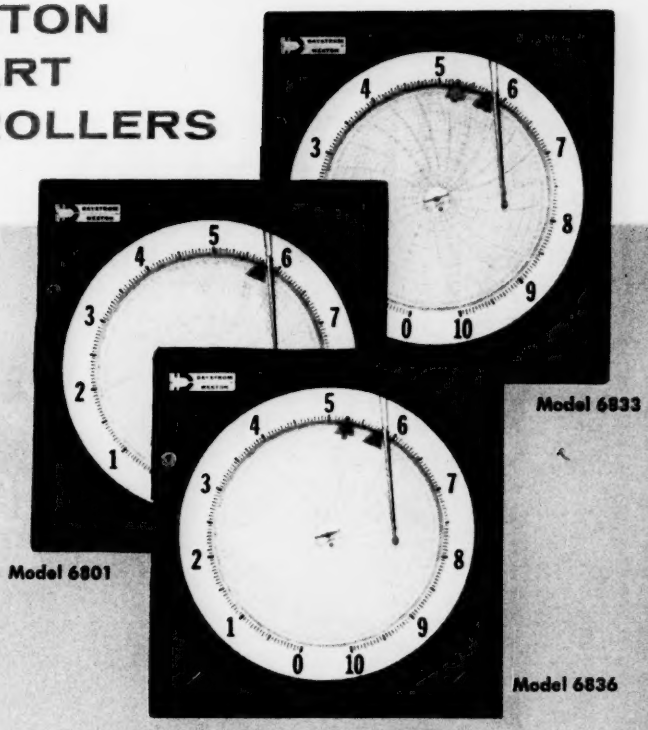
DAYSTROM-WESTON CIRCULAR-CHART RECORDERS CONTROLLERS



there's unequalled value in this newly designed series...

thanks to UNITIZATION*

All the features of the famous Weston strip-chart instruments are available in this new line of potentiometer and Wheatstone Bridge recorders and recorder-controllers. And there's a bonus in readability and easy maintenance. The basic recorder designs (Models 6801 & 6821) show their versatility in adapting to either pneumatic (6836 & 6856) or electric (6833 & 6853) control—of the 2-position, proportioning, or differential-gap varieties.

Here are some of the other dividends *unitization* brings you in this great new series:

EASIEST MAINTENANCE . . . revolutionary D-Pak Constant Voltage Supply Units eliminate batteries, standard cells and standardizing mechanisms in potentiometers. Wheatstone Bridges are equipped with Battery Eliminators. Every component is easily accessible; there's no jungle of wires to hamper inspection and servicing.

READABILITY . . . 12-inch charts, with full-scale pen travel of 4⅝ inches. 320° concentric indicating scales are 33⅞ inches long. Universal mounting permits use in the most advantageous locations.

INTERCHANGEABLE PARTS . . . exclusive universal range standards can be changed in seconds. A single slide-wire and amplifier will serve any WESTON recording potentiometer. This means *lowest spare-parts inventories.*

For more complete information, call your local WESTON representative . . . or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int., 100 Empire St., Newark 12, N. J.*

*** UNITIZATION:**
the grouping of related components—in Daystrom-Weston Instruments—in the simplest, most serviceable, most efficient manner.

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Field Engineering—Your local Honeywell field engineer—working out of one of more than 100 branch offices throughout the United States—is as near as your phone and ready to serve you.

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Quality Product—Finest construction . . . wide range of sizes . . . Honeywell quality control valves are available in literally thousands of different combinations to meet specific application needs.

Performance—"On-stream" service is assured when you use Honeywell quality control valves.

Next time you need control valves . . . why not do as others are doing. Call your local Honeywell field engineer . . . he's all ways at your service. MINNEAPOLIS-HONEYWELL, Fort Washington, Pennsylvania.

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First in Control

events

October 27-28

Radio Fall Meeting of the Electronic Industries Association, Sheraton Hotel, Rochester, N. Y. For information contact the EIA office, 11 West 42nd St., N. Y. 36, N. Y.

October 27-29

East Coast Aeronautical and Naval Electronics Conference, Lord Baltimore Hotel & 7th Reg. Armory, Baltimore, Md. For information write R. L. Pigeon, Westinghouse Fleet Corp., Air Arm. Div., P.O. Box 746, Baltimore, Md.

October 29-30

Fifth Annual Computer Applications Symposium sponsored by Armour Research Foundation, Morrison Hotel, Chicago, Ill. For information write F. C. Bock, Armour Research Foundation of Illinois Institute of Technology, Technology Center, 10 West 35th St., Chicago 16, Ill.

October 30-31

Fourth Electronic Business Systems Conference sponsored by the Western Division, National Machine Accountants Assoc., Olympic Hotel, Seattle, Wash. For information write Jack Armstrong, P. O. Box 134, Seattle 11, Wash.

October 30-31

1958 Electron Devices Meeting, Mechanics Bldg., Boston, Mass. For information write C. J. Lahanas, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

November 3-7

The American University's Fifth Institute on Electronics in Management, Washington, D. C. For information write Ruth Barker, The American University, Massachusetts & Nebraska Aves. N. W., Washington 16, D.C.

November 5-7

Society for Applied Spectroscopy Annual Meeting and Instrument Exposition and Joint Meeting with ASTM Committee E-13 On Absorption Spectroscopy, Hotel New Yorker, New York City, N. Y. For information write Paul Lublin, Sylvania Electric Products Inc., Bayside, L.I., N. Y.

November 6-7

Seventh Annual Instrumentation Conference, on campus of Louisiana Polytechnic Institute. For information write Stewart Baggarly, Louisiana Polytechnic Institute, Dept. of Mech. Engineering, Ruston, Louisiana.

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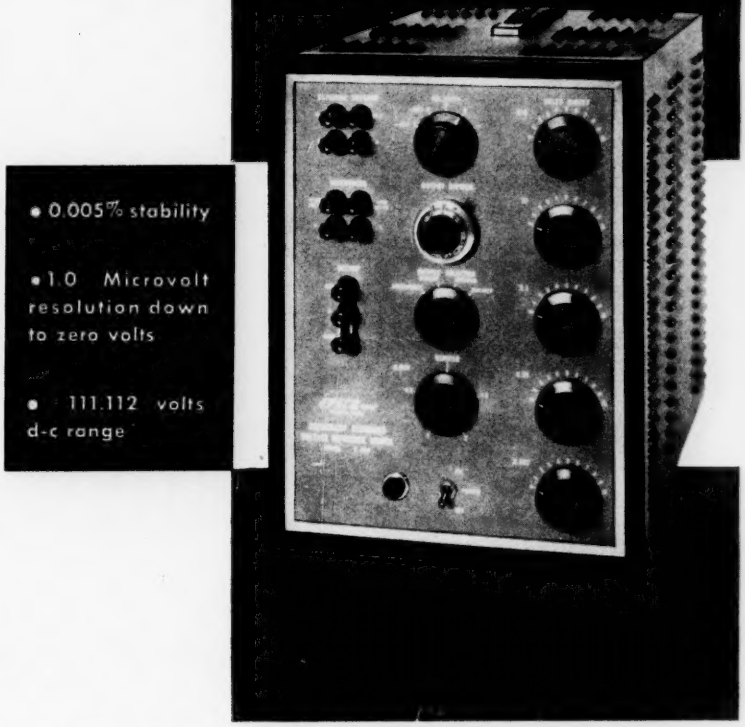
VOLTAGE SOURCES



- 0.005% stability
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• Out-perform any other voltage reference source on the market • contain highest quality components: certified standard cells, oil-immersed ultra-stable resistors, high-gain chopper-stabilized amplifiers • being used in the most demanding and critical applications across the country, such as at Convair Astronautics, North American Aviation, Argonne National Laboratory, Massachusetts Institute of Technology, Bell Telephone Laboratories, Goodyear Rubber, Patrick Air Force Base.

Want the full story? Write today for new technical brochure, covering circuit design details, specifications, operating instructions.

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Epsco, Incorporated, Equipment Division, 588 Commonwealth Ave., Boston 15, Mass.
In the West: Epsco-West, 125 E. Orangethorpe Ave., Anaheim, California

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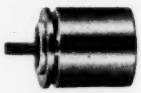
Transistorized Operations

Oster®

- Meets MIL-E-5272
- −65°C to +125°C temperature range.

	SIZE 8	SIZE 10	SIZE 11	SIZE 15	SIZE 18
Oster Type	8-5001-00	10-5052-00	11-5101-00	15-5153-00	18-5201-00
Electrical Characteristics					
Frequency (cps)	400	400	400	400	400
Torque at Stall (oz. in.)	.15	.30	.63	1.45	2.35
No Load Speed (rpm)	6500	6500	6500	5200	5200
Speed at Half Torque (rpm)	4000	4000	4000	3200	3200
Time Constant (sec.)	0.03	0.015	0.016	0.017	0.013
Reversing Time (sec.)	0.051	0.025	0.028	0.030	0.022
Theo. Acceleration at Stall (rad. sec²)	22500	45000	41500	31000	40000
Operating Temp. Range (°C.)	−54 to +125	−54 to +125	−54 to +125	−54 to +125	−54 to +125
Slot Effect	1.6v 26v	1.0v 36v	1.0v 40v	1.0v 40v	1.0v 40v
Duty Cycle	Cont.	Cont.	Cont.	Cont.	Cont.
Fixed Phase					
Voltage	26	115	115	115	115
R (Stall) Ohms	196	1270	1250	490	280
X (Stall) Ohms	183	1560	1780	890	570
Z (Stall) Ohms	268	2210	2175	1030	640
P.F. (Stall)	0.73	0.57	0.58	0.49	0.45
Effective R (Stall) Ohms	366	3840	3800	2160	1460
Parallel Tuning cond. for unity P.F. (Stall) Mfd.	1.0	0.13	0.15	0.33	0.55
Control Phase					
Voltage	40/20	40/20	40/20	40/20	40/20
*R (Stall) Ohms	480	124	145	58	39
*X (Stall) Ohms	445	215	204	103	77
*Z (Stall) Ohms	660	248	250	118	86
*P.F. (Stall)	0.73	0.50	0.58	0.49	0.45
*Effective R (Stall) Ohms	910	495	430	240	190
*Parallel Tuning cond. for unity P.F. (Stall) Mfd	0.4	1.4	1.3	2.9	4.1
Mechanical Characteristics					
Rotor Inertia (gm. cm²)	.47	.47	1.07	3.3	4.0
Weight (oz.)	1.2	2	4.5	8	14
Mounting Type	Synchro	Synchro	Synchro	Synchro	Synchro
Motor Length	.863	.672	1.703	1.625	2.03
Type Shaft	Pinion	Pinion	Plain	Plain	Plain
Shaft Extension	.375	.218	.437	.540	.540
Outside Diameter	.750	.937	1.062	1.437	1.750
Type Connection	Leads	Terminals	Terminals	Terminals	Terminals

*For 40v connection



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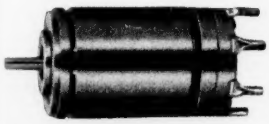

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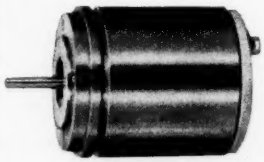

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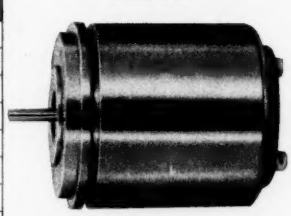

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Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Zelazo, Director of Research, in confidence.

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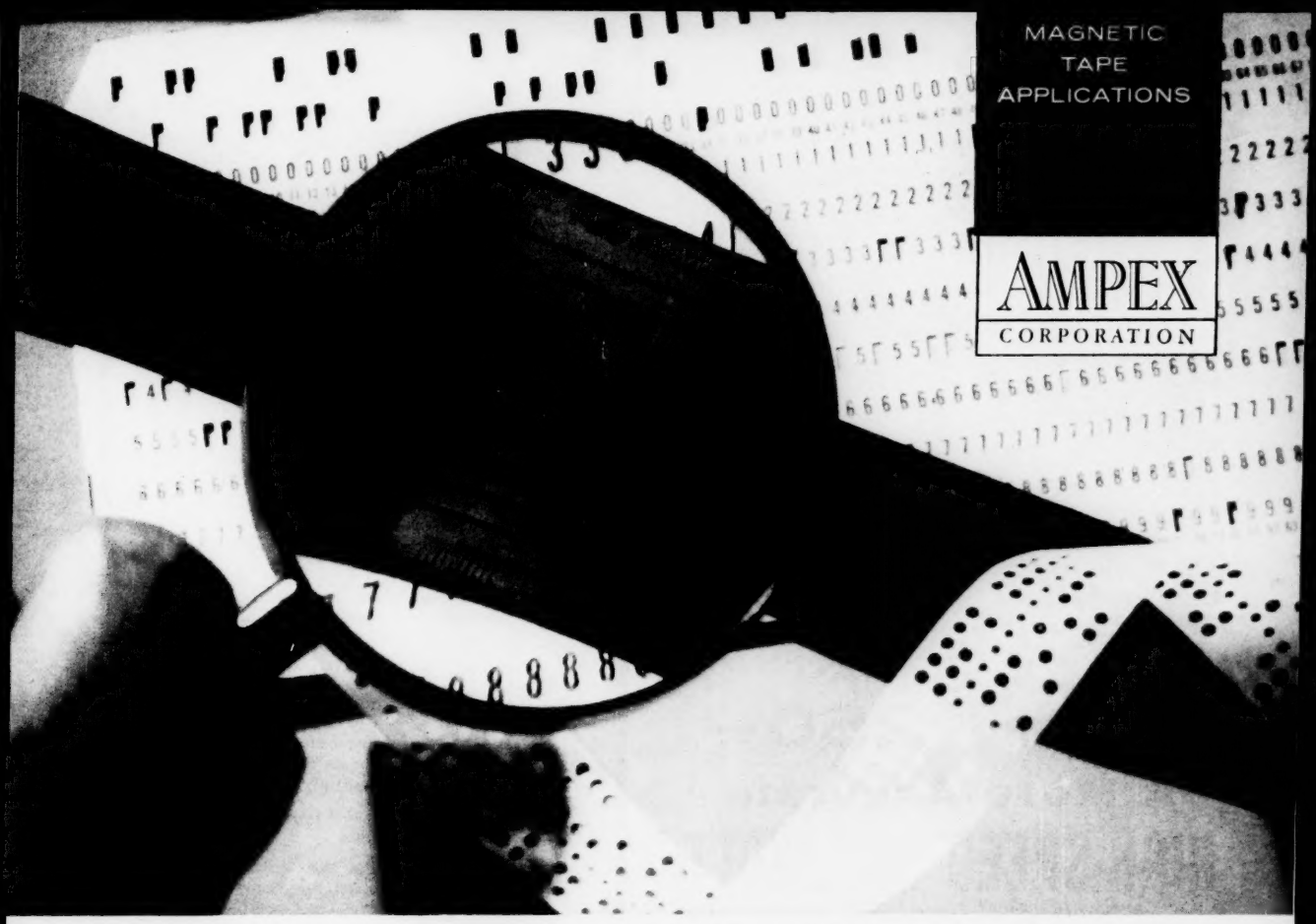

When to use magnetic tape in automatic control

Iron dust and a magnifying glass provide a revealing visual comparison

You are seeing iron dust clinging to signals recorded on magnetic tape. There can be 3200 extremely reliable binary bits on one square inch—or analog control information similarly compact. In the compacting of automatic control data, magnetic tape is supreme—second only to nature's remarkable chromosome. Nature makes people, dogs, cats and monkeys. Magnetic tape recorders make, for example, machined parts—their shapes the most complex and precise that have ever been produced in quantity. It is done by numerical control. The principles involved are very widely applicable to all kinds of control applications. Three main criteria determine where magnetic tape is your best choice.

Criteria No. 1: QUANTITY OF CONTROL DATA

Any automatic control operation that can benefit from very large numbers of time-synchronized commands is a natural candidate for magnetic tape. For example, continuous-path control of a milling cutter may require X, Y and Z coordinates at several hundred points per inch of tool movement. The more points, the greater the accuracy. A reel of magnetic tape can define millions of points at extremely low unit cost.

Continuous real-time control of variables is applicable to process programming, simulation devices, automatic inspection and electronic-system checkout—provided there is need for great accuracy in a complex situation. The program tapes may incorporate the work of giant computers and intricate interpolating devices. A great advantage of magnetic tape is that the computer and interpolator are used only during tape preparation, hence may be shared with many other needs.

Criteria No. 2: HIGH TRANSFER RATE

The Ampex FR-300 digital tape handler can spew out alpha-numeric characters at rates as high as 30,000 to 90,000 per second. A short burst of digital information equivalent to a standard punched card can be extracted from magnetic tape under 4 milliseconds—including start and stop.

On analog position-control data, magnetic tape can provide many hundreds of complete commands per second—200 per second in one example and up to eight times this many if needed.

On control-system monitoring, a recording of as much as two hours duration can be played back in one minute for review by high-speed computers. Ampex tape recorders with overall speed ratios as high as 120-to-1 are available.

Criteria No. 3: ERASURE AND RE-RECORDING

Magnetic tape can be erased to accept new data an endless number of times. Hence tape-loop recorders can operate on a repetitive cycle of recording, reproduction, erasure and re-recording to serve as time-delay devices or endless monitors. Such a loop can be the analog equivalent of a production line, conveyor belt or process flow. The loop keeps in step, accepts sensing information at one place and then triggers commands at some fixed time downstream. Or as a calamity monitoring device, the tape loop stores information briefly and erases it to make way for new data if nothing has occurred.

Can we advise you on a specific application of magnetic-tape control or send further literature on magnetic-tape recorder principles and applications? Write Dept. BB-19.

AMPEX INSTRUMENTATION DIVISION • 860 CHARTER STREET • REDWOOD CITY, CALIFORNIA

Phone your Ampex data specialist for personal attention to your recording needs. Offices serve U. S. A. and Canada. Engineering representatives cover the free world.

For more information circle **36** on inquiry card.

MICROAMMETER-MILLIVOLTMETER RECORDER PERFORMS 6 FUNCTIONS

1. Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.
2. Records on 3" continuous strip chart or IBM-type card chart, with linear coordinates.
3. Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.
4. Operates on force-balance principle—compensates for ambient conditions, changes in power supply and components.
5. Records fast—up to 0.05 seconds for 63% of fullscale changes.
6. Provides span and zero adjustments for easy calibration and zero suppression in the field, without special equipment.

For only $250— A More Accurate HIGH-SPEED MILLIVOLT RECORDER

This highly sensitive 'American-Microsen' Series 130 Recorder, with all its operational advantages, costs less than others designed for the same jobs. Simple design, precision components and rugged construction assure sustained high accuracy and freedom from maintenance. The recorder withstands shock up to 30 times gravity.

Since its introduction less than a year ago, the Series 130 Recorder has been very successful because it offers a more accurate and durable method of recording dc electrical signals at lower cost. It is being used to record outputs of many different electrical transducers – for measurement of such variables as pH, gas analysis, signal strength and others.

Many laboratories have adapted the Series 130 Recorder to their analytical and scientific instruments to assure accurate, permanent records of results which previously were only indicated. The Recorder can be used with any device which can provide 200 microamperes or more in its output circuit.

Standard 'American-Microsen' Series 130 Recorders are priced at $250.00. All models have ample power to operate alarm contacts which can be supplied at extra cost. *Write for Bulletin MG10.*

SPECIFICATION BRIEFS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts.

INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volts.

ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span.

REPEATABILITY: ± 0.25% of span.

EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.

EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed** – approximately 4 times fast speed setting.

CHART SPEEDS: Strip Chart – 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** – 1 rotation per day, standard.

SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.

PANEL SPACE REQUIRED: Only 27 square inches.

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INDUSTRIAL CONTROLS DIVISION · DANBURY, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more information circle **48** on inquiry card.

EVENTS—CONTINUED

November 6-7

Professional Group on Nuclear Science, Institute of Radio Engineers, Villa Hotel, San Mateo, Calif. For information write Mr. H. Malcolm Ogle, Mgr. General Electric's Atomic Power Equipment Dept., San Jose, Calif.

November 17-20

Conference on Magnetism and Magnetic Materials Sheraton Hotel, Phila., Pa. For information write John Leslie Whitlock Assoc., 6044 9th St., N., Arlington 5, Va.

November 19-21

Eleventh Annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minnesota. For information write Dr. Otto H. Schmitt, University of Minnesota, Minneapolis, Minnesota.

November 19-20

Northeast Electronics Research and Engineering Meeting, Mechanics Hall, Boston, Mass.

November 24-30, 1958

International Measurements Conference, Budapest, Hungary. For further information write Dr. Gyorgy Striker, General Secretary, P. O. B. 3, Budapest 5, Hungary.

November 28-December 4

Electronic Computer Exhibition (including Data-Processing Equipment), Olympia, London. For information write S. S. Elliott, 11/13 Dowgate Hill, London, E. C. 4, England.

December 2-4

Third EIA Conference on Reliable Electrical Connections, Dallas, Texas. For information write W. O. Richards, 224 Cedar St., Syracuse 3, N.Y.

December 3-5

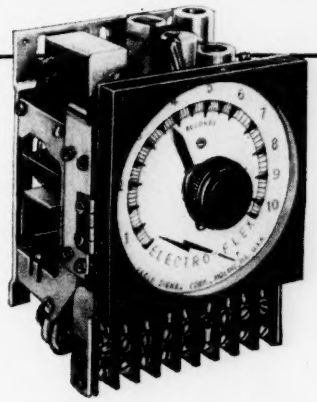
Eighth Annual Eastern Joint Computer Conference and Exhibition, Bellevue-Stratford Hotel, Philadelphia, Penna. For information write John L. Whitlock, 6044 Ninth St., North, Arlington 5, Virginia.

December 3-5

Second National Symposium on Global Communications co-sponsored by the Professional Group on Communications Systems of IRE and AIEE Communications Div., Colonial Inn and Desert Ranch, St. Petersburg, Florida. For information contact Leslie Spencer, c/o 72nd St., N. St. Petersburg, Florida.

NEW *EAGLE* ELECTRONIC RESET TIMER SPANS RANGE FROM .1 TO 10 SECONDS

... COMPENSATED CIRCUIT MAINTAINS HIGH ACCURACY



ELECTROFLEX

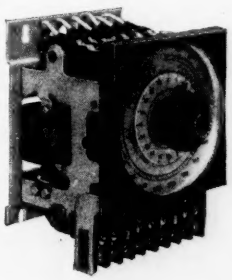
Eagle's new Reset Timer employs only two moving parts (relay armatures), achieving precise short-interval timing through a dual range electronic circuit. Timing accuracy is maintained within 2% through line voltage variations from 90 to 130v. ambient temperature changes of 52°F. to 140°F., electronic tube replacements, and vibration up to 3g.

SUGGESTS NEW CONTROL IDEAS

Electroflex Dial, with precision wound potentiometer, may be mounted at the push button station with the mechanism located at a spot more convenient to wiring, installation.

PULSER

Pulsing with adjustable dwell is easily effected. Periodic output pulses may be continuously repeated with the OFF period adjustable on the dial. Pulse length (or reset time) is .050 seconds. OFF time is adjustable to 10 seconds.

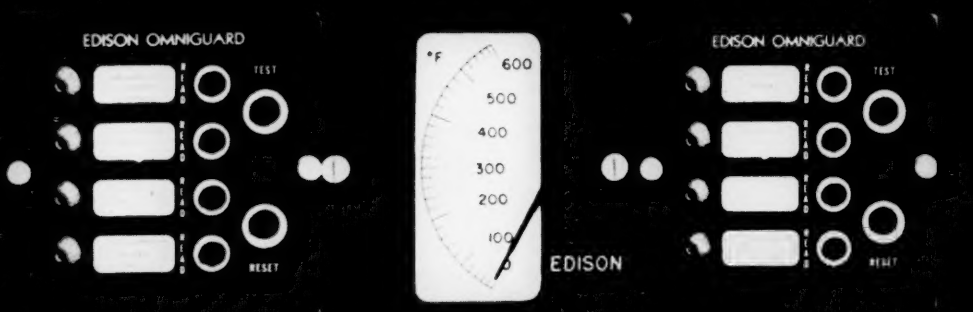


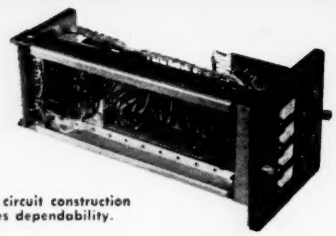
COMPANION EQUIPMENT

The Electroflex Timer, the Eagle Microflex Timer, synchronous motor driven for longer time intervals, and the Microflex Counter, (shown) all share the same large 4" dial, mounting dimensions, accessories and selection of enclosures to provide uniform appearance, simplify installations.

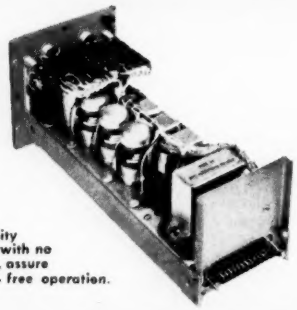
Send for new Eagle Bulletin 150. Simply write to Eagle Signal Corporation, Industrial Timers Division, Moline, Illinois, Dept. IA-1058.

For more information circle **49** on inquiry card.

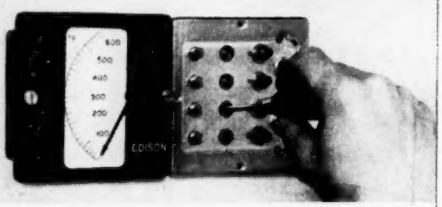




Printed circuit construction increases dependability.



Highest quality components, with no moving parts, assure maintenance-free operation.



Easy access to all components permits quick temperature settings and monitoring system changes – at any time.

Model 310 Edison Omniguard with Model 311 Indicator – a single indicator can read any number of temperature points.

THOMAS A.

EDISON

new model 310 omniguard temperature monitor... unmatched for versatility

The new Model 310 Edison Omniguard provides the simplest, most dependable temperature detection system yet devised... for both small and large installations.

The Omniguard system is reliable... flexible... economical. You order only the plug-in units needed, add new units as your monitoring needs expand.

Check these features of the new Edison Omniguard:

1. **VERSATILE:** One instrument can be used for both normally open and normally closed annunciator... for alarm or for shutdown of equipment.

2. **FLEXIBLE:** Quick, inexpensive system changes and additions . . . easy tie-in with any type annunciators or cut-off switches.

3. **DEPENDABLE:** Rugged design with highest quality components, no fragile moving parts.

4. **SIMPLE:** Single indicator reads any number of temperatures, needs no periodic adjustment. With a minute's briefing, *anyone* can operate the simple Omniguard monitoring system.

5. **LOW COST:** Plug-in units can be custom-tailored to your exact requirements . . . order additional units only when needed.

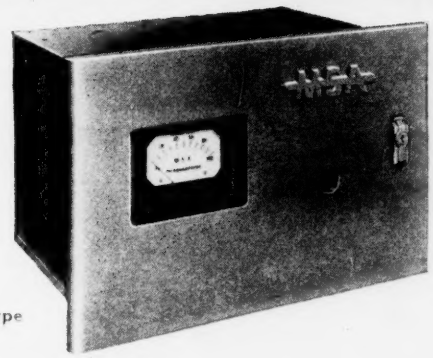
Thomas A. Edison Industries

INSTRUMENT DIVISION

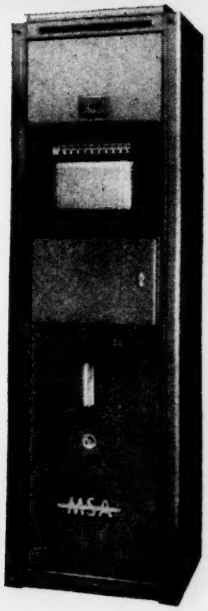
24 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON FACTORY OFFICES ARE LOCATED IN: EVANSTON, ILLINOIS; DALLAS, TEXAS; DAYTON, OHIO; SHERMAN OAKS, CALIFORNIA

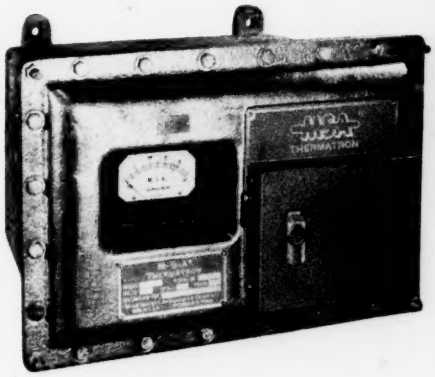
For more information circle **50** on inquiry card.



Non-explosion-proof type



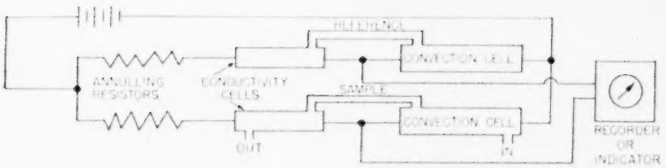
A non-explosion-proof type of M-S-A Gas Thermatron with recorder mounted in cubicle



Explosion-proof type

M-S-A® Gas Thermatron continuously analyzes for one component in multi-component gas mixtures

This unique development in gas analysis instrumentation combines thermal convection and thermal conductivity effects to provide selective measurement of a single component of a mixture without "scrubbing out" interfering components.



Schematic Flow and Wiring Diagram

MSA has been applying its knowledge of gas analysis to specific customer problems for over 30 years. Latest and most unique solution to some of these problems is the M-S-A Gas Thermatron.

This unit selectively analyzes for one component of at least a ternary mixture of gases (without removal of any component) by employing both thermal conductivity and thermal convection properties of the gas.

Other standout features: Calibration is possible over very narrow or very wide ranges (0-100% Gas). Construction is rugged. Operation is stable. Maintenance is simple, infrequent. High accuracy and speed of response are inherent characteristics.

In process control, you can use the selective M-S-A Thermatron for analysis of components in hydrogenation, ammonia synthesis, hydrocarbon synthesis and other processes.

In the area of atmosphere/combustion control, you can analyze for CO_2 or H_2 in atmospheres containing H_2, CO_2, N_2, CO and water vapor. Or, for CO_2 in flue gases.

And where gas purity is a factor, the M-S-A Thermatron is helpful in the analysis of argon, hydrogen, helium or water vapor in oxygen, air or nitrogen.

The MSA Instrument Specialist will welcome an opportunity to relate these advantages to your specific operation. Contact him soon. And write us for informative new bulletin on this inexpensive thermal conductivity analyzer.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

MSA

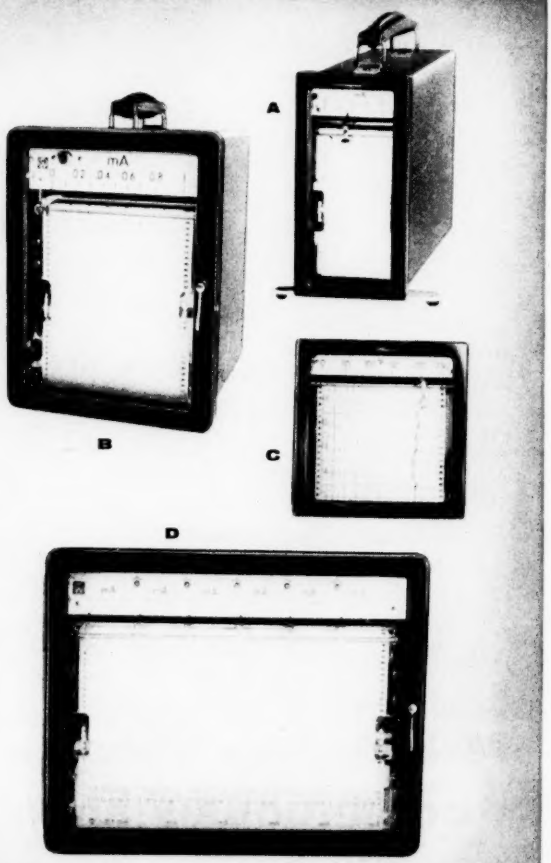
For more information circle **51** on inquiry card.

Curtiss-Wright

RECTILINEAR STRIP CHART RECORDERS

offer you

12 BIG ADVANTAGES



1 MOVING-COIL AND DYNAMOMETER MOVEMENTS — No choppers, tubes, motors, slidewires, mirrors . . . provides utmost reliability. AC, DC, and Power movements.

2 UP TO 6 CHANNELS AVAILABLE — Curtiss-Wright Double Size Models are the *only* Rectilinear Strip Chart Recorders to offer up to 6 channels. Curtiss-Wright recorders provide simultaneous recording of two to six variables on a single chart in any combination of different types of movements.

3 SENSITIVITY DOWN TO 250 UA FOR DC . . . can be extended beyond 250 ua by DC amplifier (optional).

4 ACCURACY 1% FOR MOVING-COIL RECORDERS — Conservatively rated as ± 1% of full scale for DC movements. Unusually low friction of pen against chart.

5 INKLESS AND INK RECORDING — Inkless recording is standard equipment on all but Miniature Models, on which it is optional. Cleanest, easiest method . . . a fine metal stylus "burns" the record into zinc coated chart paper. Instantly converted to ink recording.

6 RECTILINEAR RECORDING — A patented mechanical linkage changes angular motion of the needle into a straight line, giving an undistorted picture of the signal. Avoids errors and saves time.

7 THREE-SPEED TRANSMISSION plus 60:1 speed change from hours to minutes provides six interchangeable speeds in all.

8 MOTOR AND SPRING DRIVES — Syne motor, hand-wound short drive or electrically wound spring motors. Automatic chart rewind.

9 LIGHT AND COMPACT DESIGN — Small size and advanced design engineering of movement allows space and weight savings.

10 DUST-PROOF AND SPLASH-PROOF CASES — Steel cases decrease effect of stray magnetic fields.

11 SHOCK-PROOF MOVEMENT — Extra reliability when used in portable applications.

12 OUTSTANDING WORKMANSHIP — Improved design and meticulous attention to detail assure highest quality precision performance. All Curtiss-Wright recorders carry a one-year guarantee.

ILLUSTRATED ABOVE

A — MINIATURE SLIM MODELS 86 (portable) and **87** (flush). Weigh 9 lbs. 3¾" x 7⅛" x 8¾". **$295.00 and up**

B — STANDARD MODELS 81 (portable) and **82** (flush). Weigh 19 lbs. 7½" x 9⅞" x 8½". **$445.00**

C — MINIATURE SQUARE MODEL (85) Weighs 16 lbs. 5⅝" square, 12¾" deep. **$330.00 and up**

D — DOUBLE SIZE MODEL 83 (portable) and **84** (flush). Weigh 26 lbs. 12¾" x 9-13/16" x 8¾". **$860.00 and up**

Curtiss-Wright . . . a new name in rectilinear strip chart recorders . . . offers you time proven advantages in precision operation. Made under licensing agreements with Metrawatt AG . . . a leading West German manufacturer of fine instruments for over 50 years . . . Curtiss-Wright recorders combine advanced design with highest quality workmanship. Moderate in price, these fine precision instruments are rugged and reliable . . . simple to operate. Write for complete information.

ELECTRONICS DIVISION

CURTISS-WRIGHT

CORPORATION • CARLSTADT, N. J.

For more information circle **52** on inquiry card.

NEW FROM JFD Electronics

DELAY LINES

An outstanding new component series in the JFD tradition of uncompromising quality.

Now . . . after extensive laboratory research – JFD distributed constant Delay Lines to meet today's challenging reliability demands!

Designed for applications calling for short delay intervals, the new lines offer a high ratio of delay to pulse rise time, in minimum space. Available for printed circuit assembly or for conventional mounting, JFD Delay Lines meet all military requirements. They can also be modified or custom-designed to meet your most rigid specifications.

Call or write today for Bulletin 213 providing complete electrical and mechanical data. Better yet, tell us *your* delay network problem – distributed or lumped constant. Our engineering staff will promptly recommend the solution with detailed specifications for your particular application.

Characteristics:

- Precise pulse fidelity
- Operating temperature range of −55°C to +125°C
- Excellent temperature stability
- Rugged encapsulated construction resists environmental moisture, humidity, shock and vibration
- Linear phase shift
- 0.1 inch grid spacing for printed board types
- Attenuation of approximately 1 db per μ sec.

PHONE DEWEY 1-1000

Pioneers in electronics since 1929

JFD Electronics

ELECTRONICS CORPORATION

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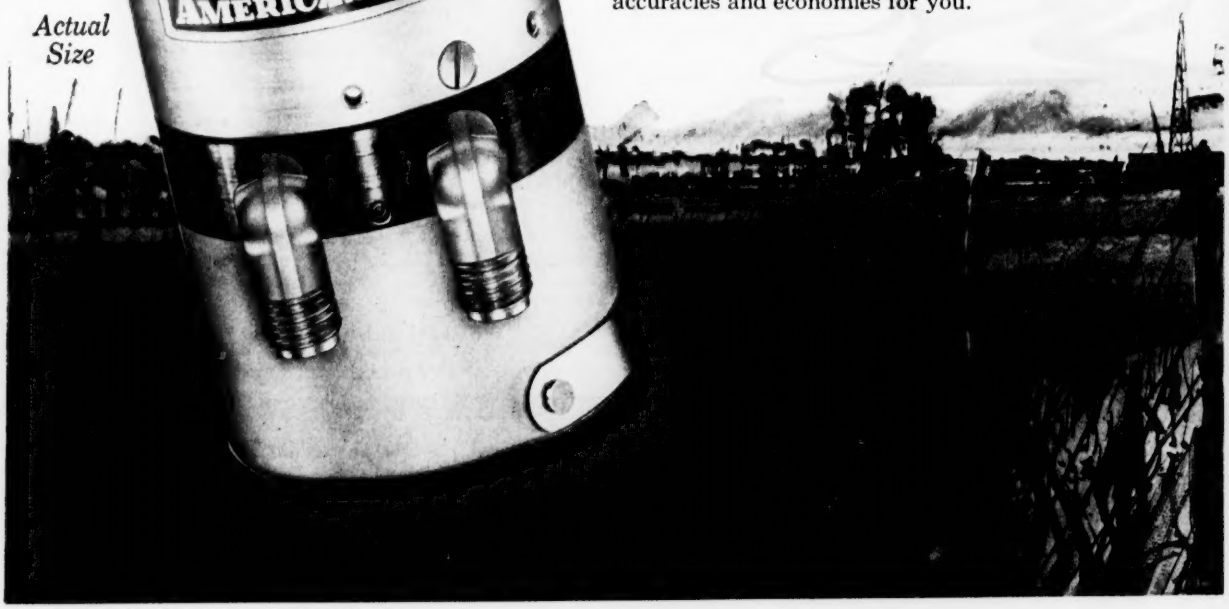
NEW American®
GASCLOK Power Drive
constant high power • uniquely accurate

Actual Size

American's new ***GASCLOK*** is a completely self-contained air or gas powered instrument drive and timing unit. Supplying a constant power output of over 20 times the torque delivered by conventional spring-wound clock mechanisms, it is ideally suited as either original or replacement equipment where continuous power and accurate timing are essential.

Perfect for all circular or strip chart records from one-hour to 30-day periods. Constant power and timing accuracy are assured since there is no "mainspring" to weaken or run down. Rugged durability and dependability are built into the ***GASCLOK*** Power Drive for years of service with minimum maintenance. It can provide new metering accuracies and economies for you.



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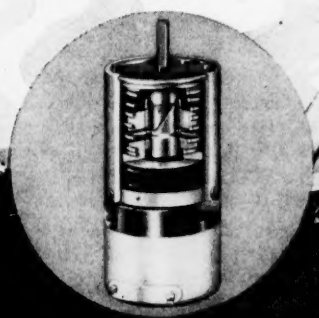
for instrument driving and timing
self-starting • air or gas operated

The versatile ***GASCLOK*** Power Drive is designed and field-tested for long trouble-free operation in remote location installations with all makes and types of recording instruments.

The high-torque, continuous drive provides power for:
Integrating Orifice Meters—Gas Lift Meters—Pressure Recorders
Strip Chart Recorders—Telecounter Units—Field Program Timers
and many other instrument applications for accurate, automatic operation.

- **Self-starting mechanism completely self-contained—requires no winding or "priming" of power unit.**
- **Gas or air consumption only 5 cfh—normal operating pressure 5 psi—rotation 2 rpm.**
- **Timing escapement spring rewound every 5 seconds—eliminates fluctuating torque.**
- **Accuracy of timing unaffected by wide fluctuations in supply pressure.**
- **Timing mechanism internally sealed to prevent corrosion and clogging—all power unit parts exposed to gas are aluminum or stainless steel.**
- **Inherently explosion-proof.**
- **Large area internal ports to prevent plugging. All internal ports easily cleaned.**
- **Installation in any position—variety of mounting brackets available.**



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AMERICAN METER CO EST. 1836 MEASUREMENT ENGINEERS

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editorial

13th I. S. A. Show

THE 13th annual ISA conference and exhibit was held September 14-19 at Philadelphia Convention Hall. The instrument industry was well represented, and many firms chose this convention to introduce new products and lines. No less than five new lines of electronic process controllers were unveiled, so that a trend to electronic control can be claimed by those who would equate commercial availability with economic applicability. Of course no such equating can be made, and no such trend can be claimed on this evidence. But henceforth the debate between electronics and pneumatics for process control will be healthier in that nobody will have a vested interest in the outcome—everybody will have both pneumatic and electronic systems for sale (the remaining two major process instrument firms without electronics line are expected to introduce them soon).

The new lines include sensors, transmitters, recorders, controllers and valve positioners—and the various signals used will further complicate the "standard electric signal" problem that has long faced the industry. Heretofore the signals in general use were 1-5 ma dc (MM&M) and 0-0.5 v ac (Autronic). The new systems use the following signals:

Foxboro Electronic "Consotrol"—10-50 ma dc (into 600 ohms)
Leeds & Northrup "Automax"—1-5 ma dc
Minneapolis-Honeywell "ElectroniK" Tel-O-Set—4-20 ma dc
Taylor Electronic—1-5 ma dc (into 6000 ohms) and 0-200 mv ac.

The fifth system, the Hagan "Powramp" temperature controller, is a magnetic-amplifier controller for control of electric heating applications up to 330 kva, with proportional, reset and rate modes.

The Taylor line includes both dc (1-5 ma) and ac (0-200 mv) units, the latter based on the LVDT (linear variable differential transformer).

The Minneapolis-Honeywell line includes both vacuum-tube and transistorized units. The 4-20 ma range was selected because this is a reliable range for transistors and because of the power available to the force coils used in the system.

The Foxboro line (10-50 ma dc) includes both transistorized and magnetic-amplifier-type controllers. The latter are used for flow control because the 30-second reset time that can be achieved with mag amps is adequate for flow control. Where reset times up to 30 minutes are required, however, as in temperature and other control situations, the transistorized controllers are used.

The Leeds & Northrup Automax Controllers (and Speedomax M, also introduced) use both transistors and vacuum tubes, and feature cascade control flexibility and rear adjustments (refinements requested by users).

In the field of process instrumentation, perhaps the most novel and unique disclosure at the show was the Swartwout "Thermo-Drive" valve actuator, which uses vapor pressure as its power medium. (This electrothermal unit is described in detail on pages 1673-74 of this issue.) Not knowing (or caring) that a previous research report had proved the impossibility of this principle for achieving the forces required for valve actuation. The Swartwout Company went ahead and produced a successful actuator that is truly unique and important to the electronic control industry.

Computer control and its predecessor, data-handling, are still exciting frontiers of process instrumentation. Big news of the show in this field was the introduction of the Libratrol-500 system of Librascope, which uses the tried and tested (200 are in use) LGP-30 as its computing heart. The price tag of $75,000 is also attractive. Thus there are now two digital computers specifically designed for process control—RW-300 and Libratrol 500—plus several others that have been adapted to the problem.

The several computer-in-control situations that are now underway must still be considered experimental in the sense that the main product is data whereby the economics of the situations are being investigated. (Thompson-Ramo-Wooldridge have announced a "cooperative development study" with Standard Oil Co. of Ohio; the Esso Baton Rouge installation is reported on page 1612 in this issue; the Esso computer-controlled pilot plant is reported on page 1688.) These basic investigations include both operating and pilot plants; the industry awaits the actual results of these investigations on which rests the future of "computers in control." This field is being closely watched by your editors.

Although the above refers to digital computers, the analog computer still offers its promise of analytical insight into the chemical process and system (a favorite editorial theme of ours for years, and the reason for the inclusion of the Simulation Council Newsletter in INSTRUMENTS AND AUTOMATION). Southwestern Industrial Electronics entered the process-control-computer field with its "Fractionation Computer," a 12-operational-amplifier analog computer for optimation of fractionation processes. Watch for some exciting news from SIE on process control by computer.

In the closely-allied field of data handling and logging, the show saw the introduction of (1) the Bailey Meter redesigned Metrotype Systems E72-1, featuring flexibility, accessibility and reliability, (2) the Honeywell 7000 Series data recorder-transcriber which samples 100 data points at 100 times/sec, digitizes, edits, and arranges data for computer entry,

(3) the Hagan redesigned Kybernetes data logging system. (4) the Texas Instruments transistorized Data-Gage. (5) the new Beckman 123 transistorized data-processing-system with 100 input channels scanned at 5 points per second: and the new 210 high-speed data system which takes 10,000 samples/sec. (6) the new high-speed Victor Adding Machine Digi-Matic, a scanning printer that prints 33 characters per second on parallel entry, 13 characters per second on serial entry. (7) the Computer Control Company new line of transistorized dynamic digital modules, including a serial memory unit with a magnetostrictive delay line, with adjustable delay up to 560 usec in one small plug-in package. (8) the new Type 5 Data-Master of Hanson-Gorrill-Brian, designed for multipoint pressure scanning and logging. (9) the new Electronic Associates' Magnetic-Tape Dataplotter (=4,016) which can convert digital data magnetic tape into inked plots at rates to 75 points/sec.

Bristol helped prepare the way for computer control of a chemical process by introducing a control station with a 4-position transfer valve—manual, semi-automatic and computer control.

A problem with magnetic data tape has been reel storage. Burroughs solves this problem via economical plastic reels which can be stored with the tape, eliminating storage transfer. Burroughs also announced a 1000 character/second paper-tape reader.

In the field of analytical instrumentation, Mine Safety Appliances introduced a gas analyzer that is sensitive to a few parts per billion, using ion chamber technique (resistance of ion chamber when matter is ionized): MSA also introduced a complete line of sampling apparatus. Davis Instrument Div. and Greenbriar Instruments introduced new lines of chromatography apparatus—both plant and laboratory, plus a Chroma-Kit to convert existing chromatography instruments to use with catalytic combustion detection. Industrial Instrument introduced the ThermaBridge, a self-contained thermal conductivity gas analyzer. Hays introduced a new BTU meter. Gow-Mac announced a line of d-c power supplies for both thermistor and thermal-conductivity cells, complete with guide to choice of proper supply for a given cell.

Of interest to measurement and control specialists were:

1. New Bristol Velotron, a low-range radiation pyrometer (0-400°F), ambient-temperature compensated.

2. New Thermodot high-speed (infrared) radiometer of Radiation Electronics Corp. of Illinois. System response time-constant of 2 ms permits temperature profiles of rapidly moving surfaces. The detector itself—photosensitive Indium Antimonide—has a time constant of *less* than 1μsec.

3. Fischer & Porter introduced a digital demand recorder for electric utility industry that counts impulses for a given time and then puts the count on punched tape: input rate is 8 pulses/sec: the instrument can accumulate 500 pulses.

4. Several new mass and magnetic flowmeters were introduced. One uses Ohmart technique for density and Foxboro technique for flow rate; the combination gives mass flow.

5. Increased flexibility for cascade control is offered in the Moore single-station cascade control station that performs all cascade functions previously requiring two stations.

6. Samuel Moore introduced Multiple Extension Wire (multiple-pair harnesses of tc extension wire); also armored, bundled copper and polyethylene tubing.

7. New "Compu-Tran" pressure transmitters of International Resistance realize accuracy with economy by use of precision potentiometers.

8. New Type 2300 Electronic Level-Trol of Fisher Governor is 1-5 ma transmitter, using the Fisher 1-5 ma electrohydraulic valve actuator; new Type 543 electropneumatic transducer converts all inputs from 1-5 to 10-50 ma into standard pneumatic outputs from 3-15 to 6-30 psi.

9. Partlow introduced several new indicating and recording pneumatic temperature controllers.

10. Gas clock of American Meter will interest pipeline men. American Meter also unveiled a semi-automatic planimeter for chart integration.

11. Fischer & Porter introduced a new mass flowmeter with accuracy of 1% of instantaneous value.

12. New Brooks flow rate transmitter converts vertical motion of flow (via magnetic helix linkage) into rotary motion of pointer and pneumatic proportional pneumatic output: integrating mechanism can indicate total flow.

13. Assembly Products entered the recording potentiometer field with a small thermocouple-actuated self-balancing temperature recorder, featuring economy.

14. Daystrom-Weston introduced a 24-point recorder said to be "smallest on market"; also a constant-current source to eliminate standard cells and a multipoint nonindicating controller.

Electronic instrument specialists will be interested in the following:

1. New "DC Differential Incremeter" of Sensitive Research expands each scale (say 0-1 ma) into ten full-scale ranges (0-0.1, 0.1-0.2, etc.) to create a 63" 1000-div. scale out of the 6.3" scale on the instrument. 2. Shockley Transistor Corp. (Beckman subsidiary) demonstrated applications of the Shockley 4-layer transistor diode. These 2-terminal bistable devices are good for oscillators, counters, etc. 3. SIE new CR-2 Time Function Translator integrates area under a curve, gives digital readout, and lamps light when transient signal is over. This is useful for chromatography as well as general integration problems. 4. Librascope introduced an Image Converter Camera with exposure times to 10 millimicroseconds. 5. Epsco introduced a neat and small transistorized digital volt-ohmmeter, plus its new high-speed TMX Series multiplexers.

Some foreign names and trademarks also will be seen more on the American market. YEW (Yokogawa Electric Works, Ltd) of Tokyo exhibited and made its debut into the American market with ammeters, voltmeters, insulation testers, recorders, oscilloscopes, pyrometers. YEW represents Foxboro and Bendix in Japan. The German Siemans flowmeters are expanding their line in the USA.

BDSA Outlook For Scientific and Industrial Instrument Industry

THE SCIENTIFIC, Motion Picture and Photographic Products Division, Business and Defense Services Administration, of the Department of Commerce, predicts that the scientific and industrial instrument industry, during the first half of 1958, will maintain the same annual rate of sales prevailing in 1957—approximately $3 billion. In the second half of 1958, the annual rate is expected to rise sufficiently to bring the year's sales to about $3.25 billion.

The forecast is based upon an analysis of the trend within the instrument industry over the past eleven years, and factors which underlie the trend. The sales figures for the eleven-year period were correlated with expenditures for new plant and equipment, Department of Defense expenditures for aircraft, guided missiles, and communications and electronic equipment, and Federal Government expenditures for increase of research and development facilities. These areas of expenditures are significant to the instrument industry, since they are closely related to instrument sales. Additionally, budgetary data on anticipated expenditures for future periods are available, thereby making the data a good base for projecting sales forecasts.

Expenditures for new plant and equipment are expected to be about $2.5 billion below the 1957 level. However, this is an aggregate figure which contains pluses as well as minuses. It is significant that the petroleum and public utilities industries, which are relatively large users of instruments, plan to increase their plant and equipment expenditures substantially in 1958. On a weighted basis, a dollar of expenditures by these industries tends to offset several dollars of negative spending by other industries.

On the plus side, government expenditures for guided missiles, electronics and communications equipment are expected to increase substantially in 1958. Consideration must be given, however, to the lag between the time when contracts are awarded, and the time when the contractors are ready to order the instruments which are related to the end products. In the correlation analysis, a six-month lag period was introduced by formulating the data on both private and government expenditures in terms of fiscal years, while retaining the calendar year basis for instruments sales data.

The scientific and industrial instrument industry has manifested a growth trend of an average annual rate of about 15%, or approximately five times that of the economy as a whole. This exponential rate of growth is attributed to the fact that instrument manufacturers have continually improved the range, precision and adaptability of scientific and industrial instruments. Technological development in instrumentation has not even begun to approach its saturation point and, therefore, this high rate of long-term growth may be expected to prevail for a considerable number of years. It is possible, moreover, that narrowing profit margins, which have been manifested throughout industry in general, may accentuate the trend, since this situation induces increased expenditures for plant modernization in order to reduce production costs.

New Glamor Subject

NEWEST GLAMOR subject in the American technical trade press is Russian education, and we can confidently look forward to an increasing deluge of papers, articles, and speeches on Russian course content, hours spent in Russian classes, comparisons of Russian and American students, etc., etc.

We predict that among the host of factors that will be analyzed in great detail and expense, the following will be noted only in passing (if at all):

1. Russia devotes about 8% of its total national income to education at all levels—compared with 4% in the USA.

2. Russia pays its superior students to go not only to college but also to technical schools—compared with considerable tuition charges in the USA.

3. Russia pays its high-school teachers and university professors much more than its skilled laborers and as much as its industrial scientists and engineers, compared with the situation in the USA where even university instructors are not paid as much as truck drivers.

4. Russia is building classrooms and educational facilities at an expanding rate, and can already graduate more than 70,000 engineers per year—compared to United States facilities that are taxed to breaking point to graduate less than 30,000 engineers per year, and where grade-school and high-school classes number 45 to 50 students (which means that each student now has a teacher only one half time).

We suggest that honest and constructive discussion of our education systems (and this does not mean the shallow mud slinging and blanket condemnation we have been served with to date) is more in order than examination of the Russian system. A good starting point for anybody who presumes to speak on education is analysis of what happened to the many school construction and staffing bills that were killed in the Congress of the USA this year.

Wheel, counter, and belt-type readouts were surveyed in the June issue. Here are details on available display-type digital readouts.

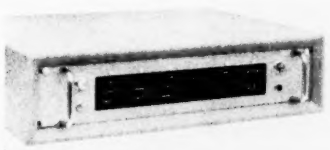
Display-Type Digital Readouts

DISPLAY-TYPE READOUTS use lamps and fluorescent materials either to form or to illuminate a number. They are not limited in size and are characterized by high data-display rate.

Prices range from $10 to $100 per decade, depending on type and features desired. The principles and features are given in the following descriptions of available equipments.

Beckman/Berkeley Lighted-Bar Indicator

PRINCIPLE—Numbers formed by miniature bulbs behind engraved bar segments on readout panel. Each numeral formed by selecting up to 7 segments. Input is received in parallel continuously from decade counter units. When enabling pulse arrives, the display responds to the input signal code, then this display is locked until next counting period is complete. Only those digits that differ from the previous display are changed.



INPUT—Four parallel binary voltages per digit (value either zero or —20 volts) from counting instruments with 1-2-2-4 code. Display is initiated by 23-v "readout" pulse.

DATA DISPLAY RATE—Up to 13 per second.

FEATURES—Bright red numerals are $\frac{3}{4}$" wide by $1\frac{1}{4}$" high on dark background. Four to six digits are displayed. Can be used in parallel for readout at remote location. Can be read through viewing angle of 150 degrees and in high ambient light.

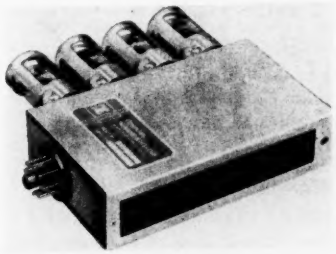
Computer-Measurements Back-Lighted Decade Counters

PRINCIPLE—Flip-flop circuitry driving neon bulbs behind engraved panel. Input pulses operate flip-flop chain connected to appropriate neon bulbs.

INPUT—Negative pulse from 75 to 150 volts peak, depending on model.

DATA DISPLAY RATE—In excess of 1,000,000 per second in Model 110A; 220,000 per second in 100A.

FEATURES—Pulses separated by as little as 0.8 microsecond can be resolved. Preset decade counting



units are available to provide an output pulse at selected numbers at rate up to 40,000 counts per second. Dimensions are $5\frac{1}{2}$" x $5\frac{1}{2}$" x $1\frac{3}{8}$".

Computer Measurements Neon-Bulb Readout

PRINCIPLE—Numerals formed by selection from 10 lamps per numeral.

INPUT—Directly into vacuum tube grids. Negative 25 volts to 0 volts for each code line. Information required is 1-2-2-4 or 1-2-4-8 binary decimal code. These codes are converted to 10-line by relay matrix; ten-line is converted by resistor matrix to proper lamps for numeral.

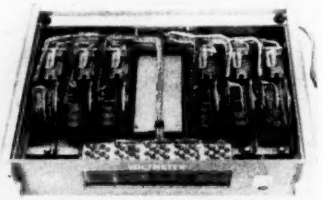
DATA DISPLAY RATE—10 displays per second with Model 150A relay-tree code converter.

FEATURES—Flat-plane numerals are $2\frac{1}{2}$" high and formed by lighting particular combinations of small, high-intensity neon bulbs that are set back in a protective grid. Display provides six-digit number. Decimal point optional. Bulb failure will not inactivate the readout or destroy the intelligence as the numbers can be understood even though some bulbs are out, which can happen only rarely. Numbers can be read at wide angle and in strong ambient light. Memory (display holding) circuit changed only on command, preventing loss of important data. Readouts can be connected in parallel for repeating in remote locations.

Cubic Corporation Edge-Lighted Plastic Display

PRINCIPLE—Edge-lighted etched-plastic plates stacked in depth. Readout unit sold separately or as digital voltmeter, ohmmeter, etc.

INPUT—Operating voltage brought to bulb terminal is 6 v at 0.2 amp.



DATA DISPLAY RATE—Thirty counts per second as digital voltmeter; average balance time for 4-place readout is 2 secs; maximum is 5.4 secs.

FEATURES—Special signs used in ratiometer, ohmmeter, etc. Each digit is a module; many can be mounted side-by-side; automatic polarity and decimal sign when used as digital voltmeter.

Dialight Read-out Pilot Lights

PRINCIPLE—Legend is hot stamped on face of lens or placed behind lens by means of a disc.

INPUT—Lamps can be selected for 1.3, 2.7, 6, 10, 14 and 28 volts.

DATA DISPLAY RATE—As fast as lamps can be lit.

FEATURES—In No. 134 series, legend is aligned after installation of pilot light. Assemblies mount in either 15/32" clearance hole from rear or front of panel respectively. In DATALITE No. 7538 series, plug-in lamp cartridge contains lens and legend.

Electro Instruments Edge-Lighted Engraved-Plastic Readout

PRINCIPLE—Lucite plates, arranged in depth, are each engraved with a numeral, letter or symbol, which lights up when the bulb at its edge is lighted.

INPUT—Bulbs are either 6v or 28 v, ac or dc, each lighted by a separate wire.

DATA DISPLAY RATE—As fast as bulb can be lit.

FEATURES—Numeral size is 1" (regular), ½" (miniature). In various colors. Standard decade has numerals 0-9, number of decades from 1 to 6. Widely used as digital voltmeter readout. Each bulb requires 1.2 watts, 6 or 28 volts. Regular unit is 2" x 2⅞" x 1⅜" deep per decade. Miniature is 2" x 1¾" x 1⅜" deep.

Franklin Electronics Back-Lighted Vertical Decade Counters

PRINCIPLE—Back-lighted engraved vertical decade counting unit in digital voltmeter Model 400A.

INPUT—Dc or ac voltage from 0.01 to 1000 volts (as voltmeter).

DATA DISPLAY RATE—Thirty counts per second as digital voltmeter: average balance time for 4-place readout is 2 secs; maximum is 5.4 secs.

FEATURES—Readout unit is compact. Voltmeter also available with Nixie readout unit.

Hewlett-Packard Flip-flop and Magnetron Decade Counters

PRINCIPLE—Neon tubes behind engraved panel. AC-4A/B counters employ a scale-of-16 binary flip-flop circuits arranged so that their count presentation is a scale of 10. Each input pulse advances the count one numeral.

AC-4D Counter unit uses a Magnetron Beam Switching tube, a high vacuum tube with a centrally located cathode surrounded by ten identical arrays. Electron beam is formed between central cathode and one of the ten external arrays or "positions." The beam can flow to only one of the ten positions at any given time. The greatest portion of the beam current flows to the target (plate) where it provides a useful output to operate a neon lamp.

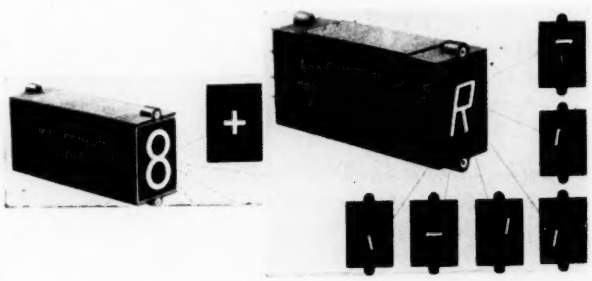
INPUT—15 v positive pulse on AC-4D; 55 to 80v negative pulse on AC-4A or B

DATA DISPLAY RATE—1.1 mc on AC-4D; 220 kc on AC-4B; 120 kc on AC-4A.

FEATURES—As the Decade Counter advance from "9" to "0", an output pulse is provided to operate the succeeding counter.

Industrial Electronic Engineers Projected-Image Indicator

PRINCIPLE—One or more of 12 lamps is lit and projects straight-line image through cutout in mask onto translucent surface. Character (number, letter, or mark) is formed by projecting either entire character or straight-line segments.



INPUT—6.3 v, 14, or 28 v ac to lamps; signal is from 12-bar matrix.

DATA DISPLAY RATE—As fast as lamps can be lit.

FEATURES—Characters ⅝" wide by ⅞" high are usually white on black; can be colored. Displays any letter A-Z, any number 0-9 and + or −; also other special marks. All characters appear on front surface. Any number of units can be combined for in-line readout. 6.3-v operation gives adequate light for most purposes and assures 10,000-hr life.

Kin-Tel Edge-Lighted Engraved-Plastic Display

PRINCIPLE—Edge-lighted plastic plates with numerals engraved in plates. Plates are stacked one behind the other. Used in digital voltmeter Model 401.

INPUT—Lamps are energized by 6 v. Voltmeter covers range of 0.0001 to 999.9 volts.

DATA DISPLAY RATE—Thirty counts per second as voltmeter with average 4-digit reading time of 1 second; maximum balancing time is 3 seconds when used as digital voltmeter (Model 401); conversion time of 3-digit Model 301 is 70 millisec.

FEATURES—Automatic polarity indication and decimal point placement when used as voltmeter readout. Includes drive for parallel input printers. Projection system uses standard lamps with 7,000 to 8,000 hr life.

Milman Engraved-Plastic Display

PRINCIPLE—Edge-lighted plastic plates

FEATURES—A quick-change molded terminal-board maintains spring-loaded contact with each bulb and eliminates the resoldering of connections when replacing bulbs. A polaroid filter covers the front of the unit to reduce incident light reflections and contribute to the sharply defined brilliance of the characters; 6, 14 or 28 volt operation.

Non-Linear Systems Edge-Lighted Engraved-Panel Readouts

PRINCIPLE—Edge-lighted engraved lucite plates are arranged one behind another (only 1½" deep). Each symbol is engraved on a separate lucite plate, and each plate has an associated incandescent lamp of the reliable aviation instrument type. Energizing a lamp causes the engraved symbol to glow brightly.

INPUT—Lamp voltage can be 6, 14 or 28 volts.

DATA DISPLAY RATE—As fast as lamps can be operated.

FEATURES—Displays having between one and six integral windows arranged side by side are available from stock in three window sizes—1" x 1", 1" x 2", 2" x 2". Complex displays available on order, or can be built-up by fastening stock sizes together. Is sealed against humidity, dust, etc. Symbol plates can be removed and replaced with differently engraved symbol plates in minutes. Standard structure permits using up to 12 plates in any one window. Is only 1½" deep.

Potter Instrument Back-Lighted Counter Decades and 1-2-4-8 Readouts

PRINCIPLE—Flip-flop circuitry driving neon bulbs behind engraved panel or beside numerals 1-2-4-8.

INPUT—30-80 volt negative pulses. Pulse width (depends on model) from 0.5 to 10 usec.

DATA DISPLAY RATE—1,000,000 per second in decade counter Model 14; 0 to 150 kc in Model 12; 0 to 40 kc in Model 13.

Potter In-Line Projection-Type Readout

PRINCIPLE—Operating on electro-mechanical principles, unit requires a 6 volt ac/dc external source to move a 0 to 9 inscribed vane in front of a light beam projected on opaque glass screen. Mechanical movement is controlled by four solenoids, each with a "weight" of 1, 2, 4, and 8.

INPUT—4-line binary decimal signal (20 volts, 100 ma) to solenoids.

DATA DISPLAY RATE:—Up to 20 numeric changes per second.

FEATURES—½"-high in-line projected readout. Single projected digit with no ghost or halo. Readout, visible from 200 feet, is 9" x 1" x 3½" high.

Victor Back-Lighted Counter

PRINCIPLE—Flip-flop circuitry driving neon bulbs behind engraved panel.

FEATURES—Conversion to nines complement for subtraction requires only 10 usec. Can accept either serial pulse train or parallel code (binary coded decimal). Display is uncoded decimal. With parallel input, a six decimal will complete all carries in 160 usec.

Westinghouse "ELF" Electroluminescent Readout

PRINCIPLE—Electroluminescent phosphor panel forms numbers by energizing selected combinations from nine straight-line segments per number (14 segments for alphanumeric).

INPUT—200 v at 400 cps across phosphor. A diode logic matrix accepts low-voltage (10 v ac or dc, 300 ma) decimal-numerical input and converts this to the required segment code.

DATA DISPLAY RATE—Several hundred counts per second.

FEATURES—Numerals can be any size (depending on manufacturing convenience) from a fraction of an inch to several feet high (first standard readout displays 2" by 2" numerals). Illumination level is about 5 foot-lamberts after 3000 hours life. Long lifetime with no sudden lamp burnout; low heat dissipation.

Recent Environmental

A continuation and extension of the environmental equipment review featured in our July issue.

Fig. 1. Walk-in chamber at Aerotest.

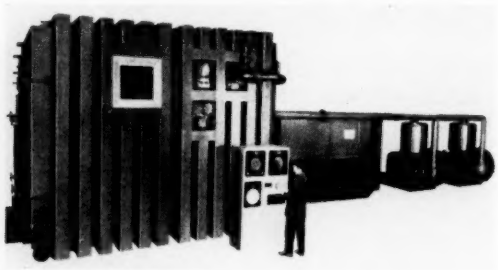


Fig. 2. ARC chamber.

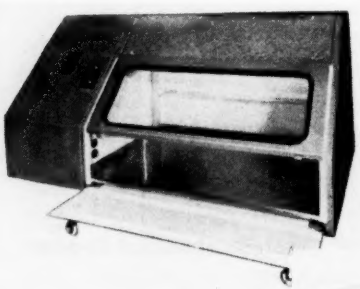


Fig. 3 Baker "Sterilshield."

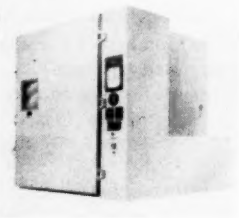


Fig. 4. Develco walk-in chamber. →

← Fig. 5. NRC high vacuum equipment.

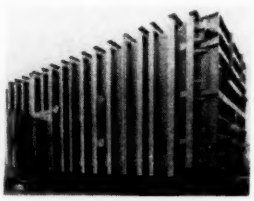


Fig. 6. Large Tenney chamber.

IN the field of test chambers for temperature, pressure, humidity and many other environmental variables, much work is underway on extension of ranges, combining of variables, and increasing chamber reliability and accuracy. Chambers are available from small "Sterilshields" to giant aircraft testers.

Fig. 1 shows a giant 10′ x 11′ walk-in chamber at Aerotest Laboratories, Inc., a complete test facility for product evaluation and design. This unit has a temperature range from −100 to +250 F, a humidity range of 5 to 95%, an altitude range of up to 200,000 ft.

Fig. 2 shows a large chamber made by American Research Corp. All chambers, regardless of size, are assembled and tested before delivery. Sand and dust chambers have automatic dust density control.

Fig. 3 shows a typical "Sterilshield" of the Baker Co., which uses low-velocity cleaned air to wash work and tools during critical operations. Parts can be transferred in cleaned air that has no particles over one micron. The Baker company also supplies prefabricated dust-controlled rooms complete with equipment.

Test chambers now being designed by Rochester Div. of Consolidated Electrodynamics Corp. will operate in regions of 10^{-6} to 10^{-11} mm Hg; one will simulate altitude of 300 miles.

Develco (Development Engineering Co.) walk-in salt spray fog chambers (Fig. 4) are lined with Monel with estimated life over 100 years. The salt solution is not re-used, but drained to waste. Top-opening chambers are lined with PVC (polyvinyl chloride).

Hudson Bay Co., Div. of Labline Inc., also uses Monel metal in its temperature-humidity cabinets, and stainless steel in low-temperature cabinets. Bakelite thermal breakers eliminate heat travel through metal.

Missimers Inc. supplies temperature chambers for rocket engines which allow vibration, tension, compression, bending and torsional stress testing while in simulated temperature, altitude or humidity environment. Temperature range is −300 to +1000 F or higher in a single chamber. Also a radiantly heated altitude chamber is capable of producing over 100,000′ altitude at temperatures up to 1200°F.

Murphy & Miller chambers also are designed for vibration testing within a temperature environment. Gradient is limited by special circulation.

NRC Equipment Corp. features high-vacuum environment (Fig. 5), which also can include heating, cooling and vibration.

Tenney Engineering Inc. can supply up to 30-cu-ft standard temperature-humidity chambers from stock.

Equipment Developments

Other designs include sand and dust, explosion, and units for use with vibration machines. A chamber recently completed (Fig. 6) has 14′ by 35′ work space, temperature range from −100 to +1200 F and an ultimate altitude of 125,000 to 150,000 feet.

Shock and Vibration Testing

Recent developments in this field include extension of ranges, high-rate testing, and automatic data plotting and analysis.

The Model 100-VA-T vibration fatigue testing machine of All American Tool & Mfg. Co. provides vertical movement of up to 100-lb assembly (Fig. 7). Displacement is adjustable up to 0.125″; frequency is variable from 5 to 100 cps; 26″ by 48″ table.

The Model 625 High-Rate Tester of Allegany Instrument Co. (Fig. 8) strains loads at rates up to 8,000″/min. An important feature is that rate is constant after first 10% of travel.

The Barry Controls T/Plotter charts the complete vibration transmissibility curve automatically and continuously during the vibration test cycle. New shock machine (Fig. 9) produces a defined shock pulse (half-sine, sawtooth, semi-square) whose wave shape, magnitude and time duration can be repeated accurately. Range is from 2 μsec at up to 700-g peak to 60 μsec at up to 25-g peak.

Continuous, visual monitoring of shaker tests from 5 to 10,000 cps is provided by "Slip-sync" and "Strobex" of Chadwick-Helmuth Co. A high-intensity strobe light is synchronized a few cps away from test frequency. Camera provides slow-motion movies of high-speed action.

The new 6″ HYGE shock tester of Consolidated Electrodynamics produces a maximum thrust of 40,000 lb. Build-up rate of 100 g's per μsec can be produced from zero to peak acceleration. Accelerations up to 2000 g's for 2 μsec have been made on an 11-lb mass.

Mechanical *reaction* vibration fatigue testing machines of L.A.B. Corp. have vibrating-members suspended and isolated to such a degree that machine producing dynamic forces in excess of 5000 lb can be installed on upper floors in multistory buildings (Fig. 10). One-minute changeover from vertical to horizontal direction is possible. Use of counterbalancing weights reduces impact on supporting structure.

Lycoming, Div. of AVCO Mfg. Corp. has developed a shock machine to meet WS-107A-2 test requirements for airborne electrical equipment that can produce sawtooth-wave shock patterns (Fig. 11) of more than 100 g's peak from 80 to more than 1000 cps. Quarter and half sine-wave shocks also can be produced.

Triaxial apparatus of Soiltest, Inc. (Fig. 12) shows performance of soils under three-dimensional stresses.

Wylie Mfg. Corp. Model W-4500 Hydrashaker (Fig. 13) is rated at 45,000-lb force and has maximum blocked force of 54,000 lb. Facility tests high flows of cryogenic fluids.

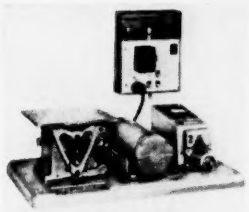


Fig. 7. All American fatigue machine.

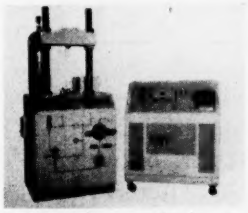


Fig. 8. Allegany high-rate tester.

Fig. 9. Barry shock machine.

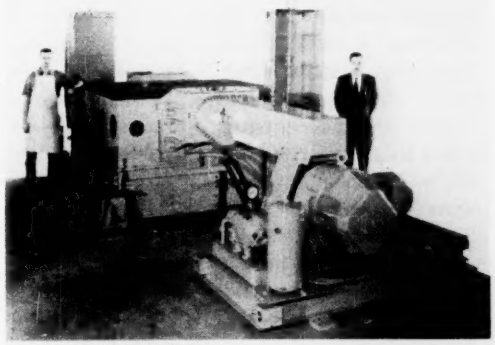


Fig. 10. L.A.B. fatigue machine.

Fig. 11. Shock pattern.

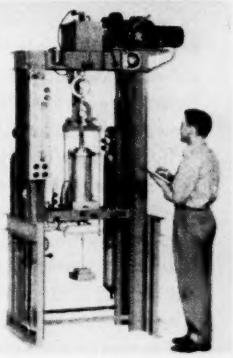
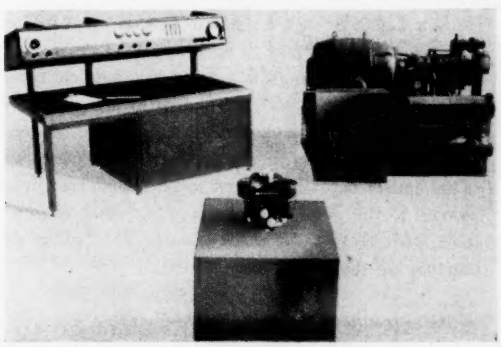
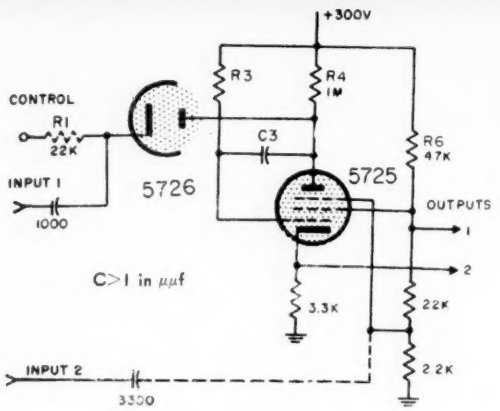


Fig. 12. Soiltest apparatus.

Fig. 13. Wylie Hydrashaker





PHANTASTRON DELAY

Widely used in radar receivers and indicators, the phantastron generates outputs of constant amplitude whose duration is closely proportional to a control voltage. It has better precision and stability than the one-shot multivibrator. Circuit shown is NBS-BuAer preferred circuit PC56. The phantastron also can be used to generate a slow, linear sawtooth waveform, and is often used in klystron AFC circuits.

Principle of phantastron operation depends on the characteristic of certain pentode tubes like the 5725 shown (a premium version of type 6AS6; subminiature equivalents are types 5684WA and 5636) to have the cathode current go to either the plate or screen, depending on the suppressor-to-cathode potential. As in other pentodes, cathode current (sum of plate and screen currents) is determined by the control grid voltage. The division of cathode current between plate and screen, however, is determined by the suppressor voltage. In pentodes suitable for phantastrons, plate current can be completely cut off by sufficient negative voltage at the suppressor grid; all of the cathode current then flows to the screen.

In the stable condition, cathode current is maximum because the control grid is biased positively, drawing current. Cathode is operating at about +12 vdc with respect to ground; hence the suppressor grid is negative with respect to the cathode, and plate current is cut off. All of the cathode current is thus flowing to the screen. Screen current, passing through resistor R6, drops the screen voltage to about 40 vdc. Suppressor voltage is about 3.5 v positive with respect to ground. Assuming the control voltage (V_c) is at its maximum value of 280 vdc, the plate voltage is also at this value.

If a negative 15-v trigger is now applied to input 1, the phantastron shifts to an unstable state. The abrupt drop in plate voltage is passed through capacitor C3 to the grid. This grid voltage drop causes a drop in cathode current, a corresponding drop in cathode voltage, and a rise in screen and suppressor voltages. This causes cathode current to be transferred from the screen to the plate because the suppressor is now positive with respect to the cathode. This plate current further decreases the plate potential.

ELECTRONIC

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Digitronics Corp.
and
MILTON H. ARONSON
Instruments Publishing Company

The action described started with a negative signal at the plate which led to increased *plate* current, which in turn caused further decrease in plate potential. This, by definition, is regenerative action, and the plate potential tends to fall rapidly. However, note that a sudden decrease in plate potential would produce a strong negative signal on the grid because the grid is capacitively coupled to the plate. This negative grid signal tends to cut *off* the plate current and raise the plate potential. Hence the plate potential *cannot* fall suddenly, but instead decreases linearly depending on the R3-C3 time constant.

A plate voltage "rundown" now occurs, with the plate voltage decreasing at a nearly constant rate. After a time determined by time constant R3-C3 (and by initial plate voltage value) the plate "bottoms" and can decrease in potential no further. At this time the phantastron begins to recover, with C3 recharging to its original condition. The grid becomes positive and the tube regains its initial stable condition. Cathode current rises abruptly to its original value, and the delay period ends. A recovery period must elapse, however, before capacitor C3 has completed recharging, and the plate voltage returned to its full original value. The circuit cannot be reliably triggered again until recovery is completed.

The abrupt changes in screen and cathode currents provide nearly rectangular waveforms at outputs 1 and 2. Output 1 is a positive-going waveform of 60-v amplitude; output 2 is a 15-v negative-going gate.

Duration of the output waveforms is closely proportional to the time constant R3-C3, and to the con-

Table 1—R3-C3 Parameters for Various Delay Periods for PC 56 and 57.

R3 megohms	C3 μμf	Minimum duration (Vc*=20v) μsec	Maximum duration (Vc=280v) μsec	Maximum recovery time [1] (Vc=280v) μsec
1.0	100	7	90	270
1.0	220	15	200	600
1.0	470	30	440	1600
1.0	1000	70	930	2700
2.2	1000	150	2000	2700
2.2	1200	180	2450	3250
3.3	1200	265	3700	3250

[1] For PC56 only; For PC57 approx. 40 μsec.
*Vc is control signal voltage

CIRCUITRY

The circuit is the heart of all electronics. Here are 2 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

trol voltage value. Control voltage range is 20 to 280 v; maximum delay time error is 0.1% of the maximum duration. Duration changes little with supply voltage changes, provided that circuit voltages and control voltage are derived from the same supply and vary together. With a common supply, a 10% change in supply voltage causes about 0.1% change in duration. A 10% change in heater voltage has the same effect. Jitter, or short-term variation in duration, is negligible in the circuit shown.

Aging of tubes causes a gradual change in duration: replacing the 5725 tube typically produces about 2% change in maximum duration. For highest accuracy the circuit should be calibrated frequently.

As shown in Table 1, recovery time (the time which must elapse before the phantastron may be triggered again) is generally longer than the delay time. In the next circuit, a cathode follower is added to reduce recovery time.

Input and outputs: See Table 2.

Control voltage, V_c: 20 v to 280 v.

Maximum error: 0.1% of max duration.

Source: NavAer 16-1-519. *Handbook of Preferred Circuits, Navy Aeronautical Electronic Equipment.* National Bureau of Standards, Washington, D. C.

FAST RECOVERY PHANTASTRON DELAY

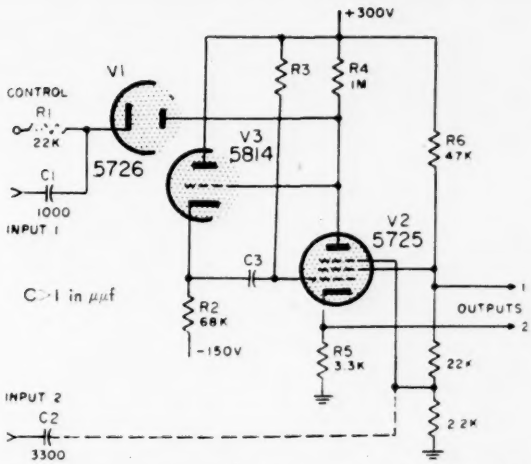
In many applications the long recovery time of the preceding phantastron circuit is not objectionable. When recovery time must be reduced, a cathode follower can be added as shown to reduce recovery time to about 40μsec. Circuit is NBS-BuAer preferred circuit PC57.

The cathode follower in this circuit couples the plate to the grid, so that the phantastron action described in the previous circuit is unchanged. However, as only tube and circuit capacitances are now present at the plate, the plate can recover rapidly after rundown.

Table 2—Inputs and Outputs of PC 56 and 57

Terminal		Amplitude v	Rise Time μsec	Duration μsec	Decay Time	Impedance Ohms	Polarity
Input	1	15	0.1	1 to 5	—	—	Negative
	2	20	0.1	0.2 to 2	—	—	Positive
Output	1	60	0.2	—	0.1%[2]	≈20K	Positive
	2	10	0.2	—	0.1%[2]	≈1K	Negative

[2] In percent of maximum duration.



The recovery time of both circuits is determined by the time for the 5725 tube plate voltage to return to its original (high) level. In the preceding circuit, recovery of the plate is slow because the capacitor C3 must recharge through the 1-megohm resistor R4. Inserting the cathode follower V3 takes the capacitor out of the plate circuit. This time-constant reduction lowers the recovery time.

Reducing the recovery time is not without disadvantages—not only is an extra tube section required (½ of a type 5814) but control voltage range is limited to the range 20-240 vdc because a minimum voltage drop across the cathode follower of 60 v is required for linear operation. Linearity of delay with input control voltage is also not as good as the preceding circuit. Maximum error is 0.5% of maximum duration; it may be reduced to 0.1% by further restricting the maximum control voltage V_c to 150 vdc.

In either circuit the control voltage source must provide a dc return path to ground to permit the clamping diode V1 to operate. Resistor R1 is needed with a low-impedance control voltage source (such as a potentiometer) to prevent short-circuiting of the trigger voltage. If the control voltage source has a minimum output resistance greater than 22K ohms, R1 can be omitted.

Either circuit can be triggered by a positive pulse at the suppressor grid (input 2) because the cathode current can be switched from screen to plate by either a small increase in suppressor voltage or a small decrease in cathode voltage. Triggering the suppressor is more critical because the trailing edge of the trigger may tend to end the phantastron cycle prematurely.

The phantastron is also used to provide stable fixed delays up to 0.1 second or more in applications such as frequency dividers. It can also be made free-running by reducing the value of the cathode resistor R5.

Inputs and outputs: Same as preceding circuit.

Control voltage, V_c: 20 v to 240 v.

Maximum recovery time: 40 μsec approx.

Maximum error: 0.5% of max. duration.

Minimum duration: See table 1, preceding circuit.

Maximum duration: Approx. 85% of fourth column, table 1.

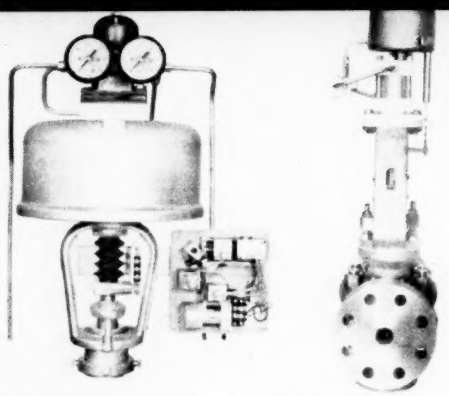


FIG. 20. ANNIN Model 30,000 electropneumatic actuator (left) and Model 20,000 electrohydraulic actuator (right).

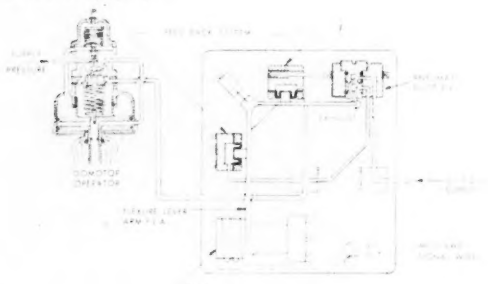


Fig. 21. Operation of Model 30,000.

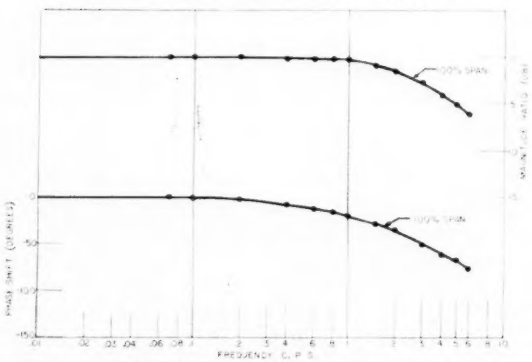


FIG. 22. RESPONSE of Model 30,000 with 0.6 cu in downstream volume: sinewave signal.

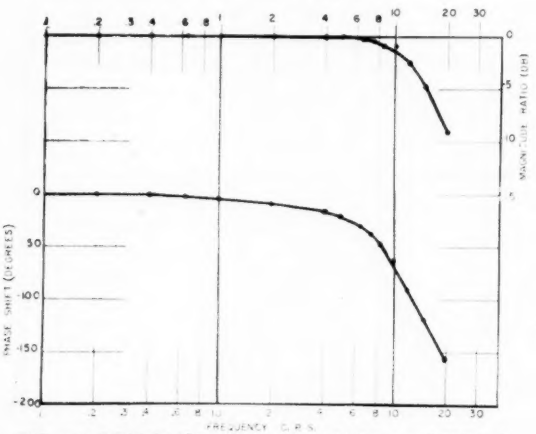


FIG. 23. RESPONSE of Model 20,000 using 3000-psi hydraulic system and operating a 3"-bore x 1"-stroke cylinder.

Response of

Annin Electropneumatic Actuator

THE ANNIN Model 30,000 *electropneumatic* actuator (Fig. 20, left) converts a d-c milliamp signal (1.0 to 5.0 ma or 5.0 to 50.0 ma) into the standard 3-to-15 psig pneumatic signal.

As shown in Fig. 21 the input electric signal moves a Y-shaped flexure lever arm via a magnetic coil. The opposite arm of the Y moves the pneumatic pilot to cause the air pressure output to increase or decrease. This output air is used to impose an opposing motion to the flexure lever, so that the output air is proportional to input signal regardless of arm position.

The pneumatic feedback signal is fed to two feedback pneumatic cells within the transducer. The upper cell is closer to the pivot than the lower cell so that the resulting moment opposes that of the magnet-coil.

The pneumatic output of the transducer is fed to the small volume of a standard Annin positioner, as shown: the positioner output is not fed back to the transducer.

The response of the Model 30,000 transducer with 1-5-ma input (12000-ohm coil) and 3-15 psi output is shown in Fig. 22 for a sinewave signal, 22-psi pneumatic supply, and 0.6 cu in downstream volume.

Annin Model 20,000 Electrohydraulic Actuator

The Model 20,000 (Fig. 20, right) can be used with most commercial electronic controllers. The domelike housing encloses a feedback potentiometer, a power supply and a transistorized amplifier (pump is external). Signals from the controller move a hydraulic servo which controls 1000- to 3000-psi fluid to the cylinder actuator. Position feedback voltage to the amplifier is taken from an infinite resolution rectilinear potentiometer. Thrust loads of more than 100,000 pounds can be developed. Various speeds of operation can be obtained by using different size standard hydraulic servo valves.

Average stem loads of 20,000 lbs and stroke speeds

Combination Valve Actuators

Last month the actuators of Conoflow, Moore, Fisher Governor, GPE Controls, Hagan, and Manning, Maxwell & Moore were discussed. Here are the Annin, General Controls, Mason-Neilan, Midwestern, Moog, and Swartwout combination (combined pneumatic, hydraulic or electronic) actuators, including the new Swartwout "Thermo-Drive."

faster than 1"/sec require a large hydraulic supply. Typically, a 3-hp motor with pump, unloading valve, and 10- or 20-gallon accumulator are used. This is too large for valve mounting: one supply can power several operators.

Response of one particular assembly using a 3000-psi hydraulic system is shown in Fig. 23. The test was run with (1) 780 to 830 psi, (2) a sinusoidal signal of 10% full amplitude, (3) a 10-gpm hydraulic servo, (4) a 3" bore x 1" stroke cylinder.

Under these conditions a response time T (time for 63.2% of full response) of 0.08 second was obtained for the 10% stroke; this increased to 0.70 second for 80% stroke.

General Controls Hydramotor

The General Controls Hydramotor (Fig. 24), is an electrohydraulic actuator (Fig. 25). A reciprocating pump develops pressure for the spring-loaded piston. The pump will run until full stem travel operates a limit switch to stop the motor. Another circuit controls the opening and closing of a relay-actuated relief valve. The relief valve will release the pressure upon the piston to allow the spring to move the stem. The entire pump and relief valve system runs in a hermetically sealed oil reservoir.

Units vary from the smallest, which is about 4" in diameter and 6" high with a stem output of 180 pounds through $\frac{3}{8}$" travel, to a power unit not much larger, which has a total stem force of 6000 pounds through $4\frac{1}{2}$". A variation of the system employs two power units—one exerting pressure in one end of a piston and the other forcing it in the opposite direction.

Numerous control circuits allow for a variety of operating cycles. This actuator was originally developed years ago as an emergency on-off current-failure unit.

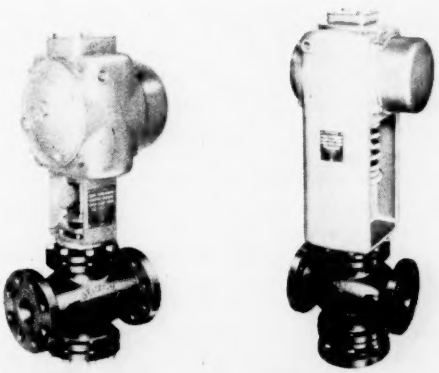


FIG. 24. GENERAL CONTROLS Hydramotors.

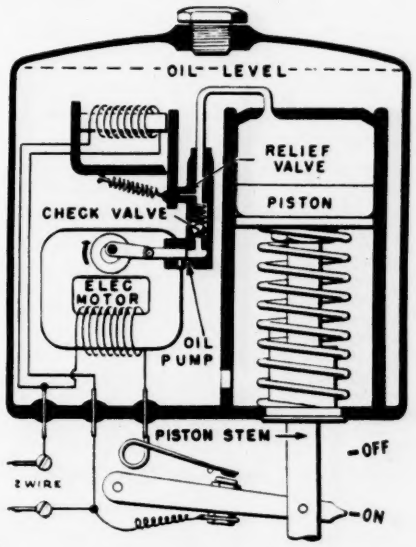


FIG. 25. PRINCIPLE of Hydramotor.

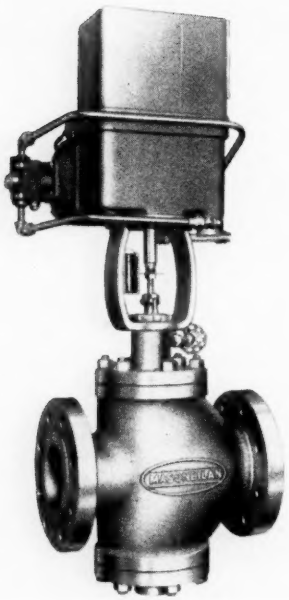


FIG. 26. MASON-NEILAN Series 250 electrohydraulic actuator.

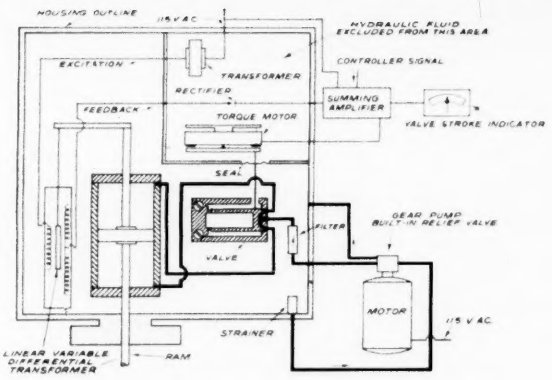


FIG. 27. SERIES 250 schematic. A torque motor positions a pilot that controls hydraulic fluid to the positioning cylinder. Feedback is taken from an LVDT.

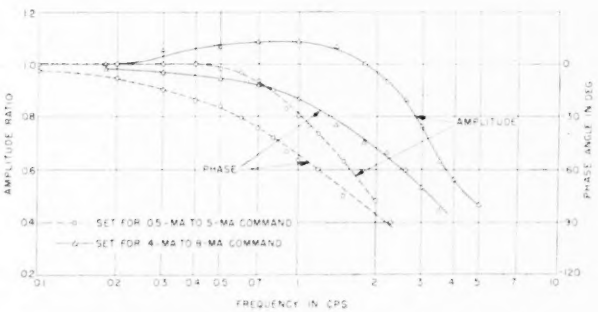


FIG. 28. RESPONSE of Series 250 actuator. The 0.5-to-5.0 ma input is for any impedance up to 3000 ohms. The 4-8 ma command is for an 18,000-ohm impedance (now 1-5 ma into exactly 12,000-ohms).

Hydramotors become fully modulating by use of a circuit which allows the stem movement to follow the dictation of a potentiometer. (This potentiometer may be operated manually or be a component of a controller.) Unbalance between the *operating potentiometer* and a *follower potentiometer* will move the armature of a proportioning relay so that the pump motor is energized through one power relay (or the relief valve is de-energized through another power relay). Upon resuming balance, the armature will assume a neutral position, opening both contacts. Limit Control may override this automatic control. Saturable reactors are used in the high capacity power units to decrease the load on the proportioning relay and increase the life of the contacts. The Hydramotor may be adapted to use with a pneumatic controller by use of a pneumatic-electric transducer, which varies the position of the controlling potentiometer in direct ratio to the 3-15 psig output of the controller.

Adaptation of the Hydramotor to an electronic control system is accomplished by running the pump continuously (or until it reaches limit switches) and controlling the rate of flow through the relief valve. Continuous feedback balance is maintained between stem position and the relief valve flow rate.

Mason-Neilan Series 250 Actuator

The Series 250 Electrohydraulic Actuator (Fig. 26) is especially suitable where electronic controls are now in use or projected, as for example, in petroleum or gas pipeline stations. Premium dynamic performance is obtained by electrical feedback, which assures repeatability, linearity and load sensitivity, resulting in precise positioning. The unit provides stroke of up to 4 inches and develops up to 3500 pounds thrust.

All parts, except the motor and pump, are contained in a two-piece cast aluminum housing divided into wet and dry sections. The wet section contains a four-way pilot valve, ram, filters and a linear variable differential transformer. It also serves as the hydraulic fluid sump. The dry section contains the torque motor, excitation transformer, position potentiometer and electrical circuitry. The dry section is isolated from the wet section by a flexible seal.

Performance data are as follows:

STROKE SPEED is 1/3" per second from no load to 2800 lb load. Stroking range is adjustable from ¼" to 4".
MAXIMUM (INSTALLED) THRUST is 3500 lb.
LOAD SENSITIVITY (stiffness) is less than 0.5% of stroke for load of 2800 lb.
POSITIONING ACCURACY (repeatability) is within 0.002" at constant load.
LINEARITY is within 3% of stroke.

Fig. 28 shows the response of the Series 250. The curves were run with a low-amplitude sinusoidal input giving an actual stem motion of 0.030".

Midwestern Model 80 Servo Valve

This unit (Fig. 29) is the newest addition to Midwestern Instrument's servo product line. Features include single-stage construction and reliability with linear static flow characteristics; a pressure-balanced

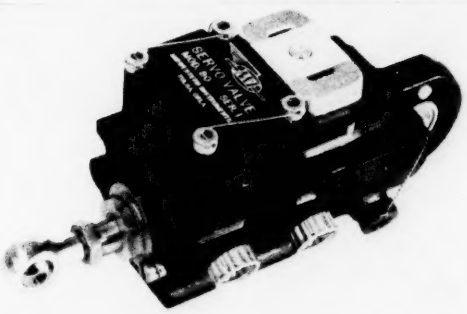


FIG. 29. **MIDWESTERN** Model 80 servo valve with actuator.

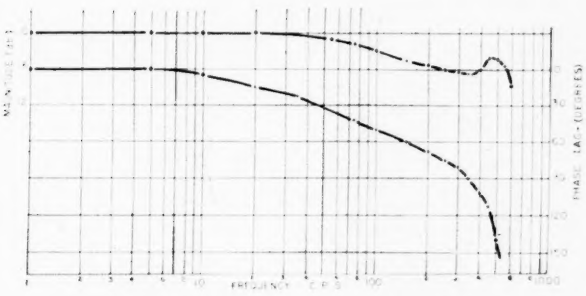


FIG. 30. **RESPONSE** of Model-80 Serial-1 servo valve. Rated flow is 1.0 gpm; supply pressure is 2000 psi.

slide plate is driven directly by a high-force torque motor. The single-stage construction eliminates the high quiescent flow that is required for the first stage of a two-stage servo valve.

Frequency response in the order of 90° at 340 cps (Fig. 30).

Performance characteristics are good when operated on either oil or air; the pressure bearings in this unit eliminate the "galling" problem of spool-type valves when operated on air.

It can operate at low supply pressures without deterioration of performance characteristics. By contrast, two-stage servo valves which depend on a hydraulic amplifier for the first state exhibit a deterioration of performance below 500 psi.

Moog Valve Electrohydraulic Actuator

The Moog Valve Company has developed and built a prototype electrohydraulic valve actuator (Fig. 31) with dynamic performance closely approximated by the following equation:

$$\frac{Y}{i}(s) = K\left[\frac{1}{(s/\omega_n)^2 + 2f/\omega_n)s + 1}\right]$$

where $\omega_n = 9$ cps (56 radians/sec); $f = 0.71$.

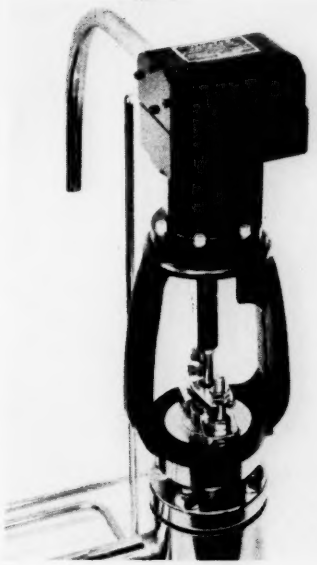


FIG. 31. **MOOG** electrohydraulic servo valve with actuator.

The actuator provides the following performance specifications:

Maximum Thrust: 1500 lbs
Maximum Piston Velocity: 4.4 inches per second
Piston Stroke: 1 inch
Input Control Signal: 1-5 milliamperes
Operating Pressure: 750 psi
Linearity: 0.5% of stroke

Frequency Response at 5 cps: Phase shift is 45°; amplitude ratio is 0.95.

Frequency Response at 11.5 cps: Phase shift is 90°; amplitude ratio is 0.71.

Swartwout "Thermo-Drive" Actuator

The Swartwout "Thermo-Drive" electrothermal actuator (Fig. 32) operates on a principle that differs completely from other combination actuators. The actuating force is the vapor pressure of Freon.

The Freon is shown as the shaded area in Fig. 32. A heater immersed in the Freon heats the Freon so that vapor is produced in the area just below the pilot valve shown. The vapor pressure determines the pressure (P_1) which exists in the volume around the bellows, which pressure acts downward on the stem.

The pressure in the volume immediately above the pilot valve will be a lower pressure (P_2) owing to the lower temperature of the Freon in the cooling lobes, which are in contact with radiating cooling sections. Thus the pressure available to force the valve stem down depends on the action of the pilot valve. If it opens, the pressure is reduced; if it closes the pressure builds up.

This force is controlled by action of the force coil, which receives the d-c input signal. Feedback force via the spring (shown schematically) gives linear response

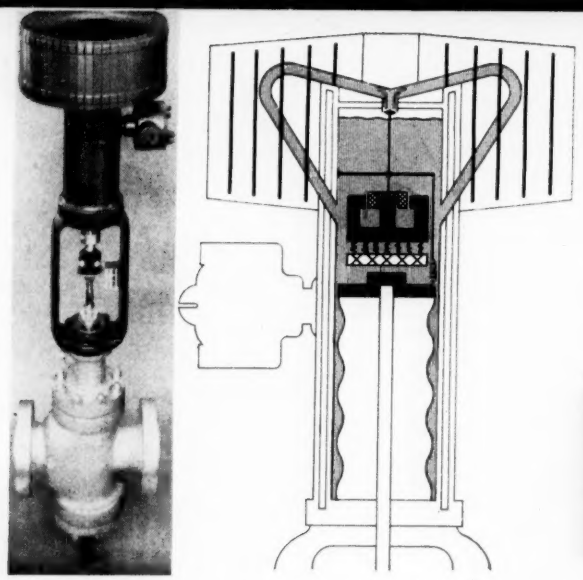


FIG. 32. NEW Swartwout electrothermal "Thermo-Drive" uses vapor pressure as power medium.

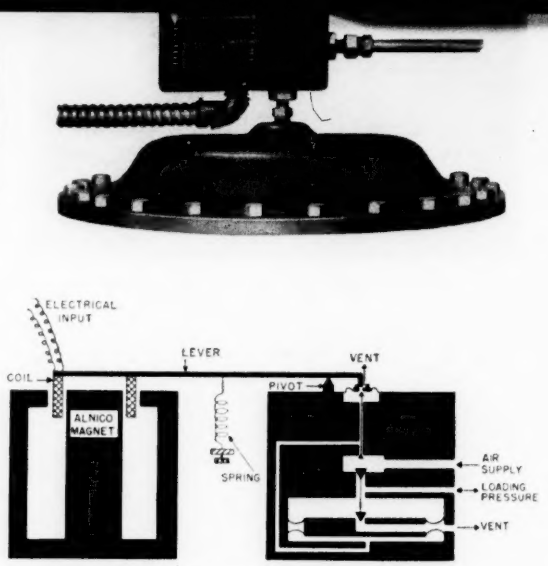


FIG. 33. AUTRONIC Type P2R power relay.

In action, a d-c signal moves the force coil slightly. If the pilot valve closes, pressure builds up in the actuator volume, moving the stem downward until the spring feedback force exactly equals the d-c signal force; if the pilot valve opens, vapor enters the cooling volume, pressure on the actuator is reduced, and the stem moves up until the force-coil force and spring force are again exactly in equilibrium. The bellows is designed so that it exerts an upward force of 300 lbs when fully compressed.

The actuator linearity is not affected by ambient temperature, radiant heat, or weather so that the internal heat-balance principle accurately reflects the control signal. All moving parts are not only hermetically sealed but completely submerged in a non-corrosive dielectric fluid which is non-explosive, non-flammable, and non-toxic. The actuator is suitable for Division 1 applications.

The stem retracts on power failure. The power supply for the heater is 115 v, ac or dc, unregulated and noncritical.

Response specifications include:

Response Speed: 0.1 inch per second.

Max Stem Loading: Actuating force is 500 lbs opposed by 300-pound return spring force.

Stroke: 1.5 inches.

Input Signal: 1 to 5 ma dc; input resistance is 12,000 ohms.

Sensitivity: 0.1% of input range.

Load Sensitivity: Less than 1.5% displacement produces full rated thrust.

Swartwout-Autronic Actuator

The Swartwout Autronic Type P2R Power Relay (Fig. 33) is an electropneumatic transducer which converts direct current into proportional air pressure to operate pneumatic valves. It is a null-balance unit in which a magnetic force is balanced against the force produced by the air output pressure from the pneumatic pilot to obtain an accurate linear relationship between the electrical input and air output.

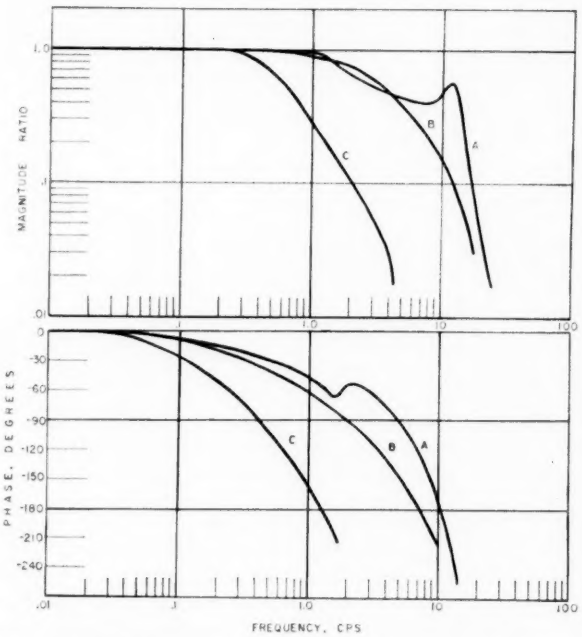


FIG. 34. RESPONSE of Autronic P2R with span of 3-15 psi, input signal of ±5% of span, and an external volume of 0 cu in (A), 6 cu in (B), and 200 cu in (C).

The electrical portion of the power relay consists of a moving coil in a permanent magnet field (Fig. 33) and is adjusted so that the d-c current input of 1 milliampere will cause 3-psi air output, and an input current of 5 milliamperes will cause 15-psi air output with a direct-acting power relay. The coil is connected solidly to a lever which transmits a force to the air portion of the power relay. Unit is available with other air outputs—namely, 3-27 psi and 6-54 psi. Explosion-proof as well as standard constructions are available.

Fig. 34 shows the response of the power relay at various values of external volume.

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Phase Relations in Delay Lines

ANY device which has a phase characteristic dependent on frequency can be used as a delay network. This follows from the definition of delay—which can be expressed in terms of the slope of the phase shift curve versus frequency, expressed in radians per angular velocity.

The relationship for constant-delay networks (such as delay lines, low-pass and band-pass filters) is as follows: If the phase slope $d\phi/d\omega$ is constant, then the instantaneous delay also is constant.

Fig. 1 shows the curve of phase versus frequency of a full section low-pass filter. The phase angle is given by $\sin \phi/2 = f/f_c$. For small angles the delay as given by the tangent to the curve is relatively constant: but as f is increased the delay increases considerably and is theoretically infinite at the cutoff frequency f_c.

This curve can be straightened out for a large part of the range (b in Fig. 1) by adding a phase-correcting network. The instantaneous addition of the ordinates of both curves would produce a phase curve essentially linear for a large frequency excursion.

The same method can be applied to a band-pass filter whose elementary section is shown in Fig. 2.

However, it is not economical to manufacture band-pass filters with complex elements and phase-corrective networks because of the large number of elements necessary to produce a satisfactory attenuation curve. It is better to combine the best features of rapid attenuation with phase linearity.

This is done in a new telemetering filter that uses essentially the lattice network shown in Fig. 3, modified for use in unbalanced-line three-terminal networks. The attenuation curve shown is for an RDB channel 12 (10,500 cycles). The delay at the center is approximately 1.3 milliseconds and holds to better than 5% over the pass band.

Toroidal cores are used to achieve low insertion loss. The core materials are compounded to meet the frequency range desired for the given application.

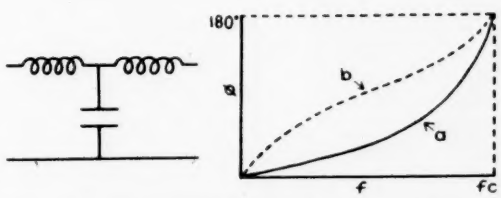

FIG. 1. PHASE VS FREQUENCY for a typical low-pass filter (a). Curve (b) shows improved linearity from addition of phase-correcting network.

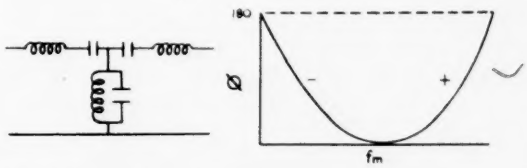

FIG. 2. BAND-PASS FILTER and its phase response with frequency.

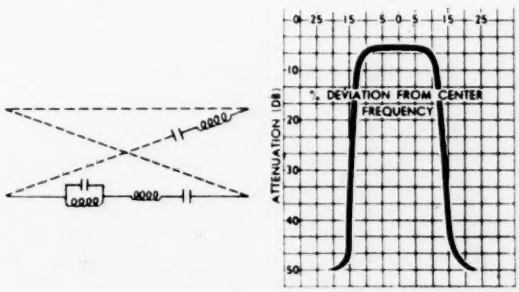

FIG. 3. LATTICE NETWORK and its band-pass characteristic showing sharp cut-off.

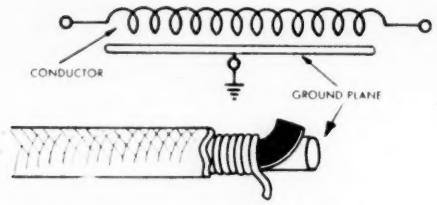

FIG. 1. DISTRIBUTED-CONSTANT delay line.

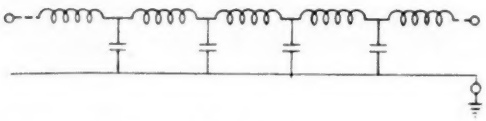

FIG. 2. LUMPED-CONSTANT delay line.

Basic Types

Basic types of delay lines include distributed-constant, lumped-constant, ultrasonic, magnetostrictive, semiconductor, and tape-recorder types.

DELAY LINES have come into prominence only within the last few decades, but at present are marketed by nearly a hundred companies in the United States for a gross volume of several million dollars.

Delay lines are basically information storage elements and can be used in many ways—from the simple delay of an oscilloscope signal until the sweep circuit is established to the application of auto-correlation techniques for detecting small signals in noise.

The basic types of delay lines are:

A. Transmission lines
B. Distributed constant or wirewound
C. Lumped constant or artificial
D. Ultrasonic
E. Semiconductors
G. Simulated types—tape or wire recorders, mechanical programmers, etc.

Transmission lines

Transmission lines of all types, from power lines to waveguides, will delay a signal for a time almost equal to the line distance divided by the velocity of light. Distortion will be small if (1) the losses are low at the frequencies involved, and (2) the line is properly terminated to prevent standing waves.

Distributed Constant or Wirewound

These delay lines (Fig. 1) have been developed from the Coaxial transmission types, but the velocity is slowed down by increasing the capacity and inductance per unit length by using materials with high dielectric or permeability constants. The range of suitable low-loss materials is limited, although the barium titanate ceramics and ferrites developed recently give considerable improvement.

The most common technique is to use a coaxial-type structure in which the inner or outer conductors, or both, are solenoids rather than continuous surfaces. The inductance per unit length can be built up to large values, but the interturn capacities act as shorting capacitors along the helix and the performance with frequency falls off long before reaching the upper limit determined by the natural resonant frequency of each turn.

Kallman[9] has improved the performance of these wound delay lines by placing conducting strips between the inner and outer conductors and insulated from them. This has increased the distributed capacitance without serious distortion, and delay lines with 10-20 Mc bandwidth and delays of 1-2 microseconds per foot are available.

A more recent technique[13] is to wind the helix so that the plane of each turn is at a considerable angle with the axis. The relationship between the mutual and self inductance of each turn then compensates for the phase distortion more adequately. The mathematical analysis of these types is still being evolved and further improvements may be expected.

Lumped-Constant or Artificial Delay Lines

These are the oldest types known and were introduced by Steinmetz in the early days of telephone work to compensate for phase distortion in the transmission lines. Structurally they are made up of separate resistance, inductance and capacitance elements in a symmetrical T or Pi network which can be repeated in identical sections throughout the line except for the terminating sections (Fig. 2).

The design of these lines is straightforward and similar to that of filters. Each element or section can introduce a phase shift in the signal which is additive. At a particular frequency f, the delay is $\phi/2\pi f$, where ϕ is total phase shift.

Artificial lines can be band-pass, low-pass or high-pass types and are designed to meet specific impedance or loss characteristics. Because of the discrete character of the reactive elements, linear phase change cannot be

# of Delay Lines

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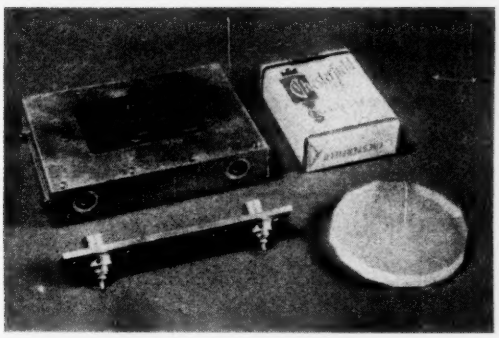
Arenberg Ultrasonic Lab., Inc.



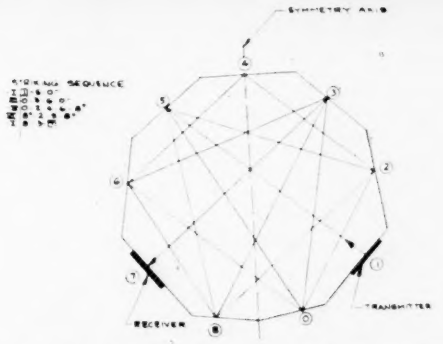


FIG. 3. ULTRASONIC DELAY LINE, showing path of sound beam.

maintained over a wide range of frequencies and signal distortion occurs, with a definite cutoff or upper limit to transmission. Dividing the line into small sections of equal delay improves the performance and the upper limit. In the limiting case, the line resembles a distributed-constant type.

The design of these lines often has followed the theory for filters of Tshebysheff and Butterworth, and various criteria based on CW analysis have been used. Selection on the basis of transient response will lead to different values; the importance of this should be recognized.

While most of the delay lines are used in low-power applications representative of communication problems, the lumped-constant types are used frequently in high-power pulse-forming networks because the large capacitors can store considerable energy. The delay lines in some radar systems can handle megawatts.

Ultrasonic Delay Lines

These came into being during World War II for radar and computer applications. Their basic characteristic is that the signal is a mechanical wave in a solid or liquid, although a gas might be used. The advantage is that the velocity of sound is about 1/200,000 that of light, permitting compact designs. The sound wave is generated by a transducer at the input (Fig. 3), which converts electrical energy into mechanical energy; another transducer at the output converts the received sound back into electrical energy.

The transducers are piezoelectric crystals (usually quartz with some applications using barium titanate) cut to generate either pure longitudinal or transverse modes. Although it is possible to apply the signals directly to the crystals, more faithful reproduction of the envelope of the information is achieved by using the signal to modulate a carrier wave at about the center frequency of the transducers. This is due to the fact that the output of the crystals is the *derivative* of the applied force; as the derivative of a sinusoidal wave is always another sinusoid, the second derivative of the modulated carrier will follow the input envelope.

With proper construction an ultrasonic delay line can have a bandwidth of 50-70% of the carrier frequency even for long delays; a 25-30 Mc bandwidth at 1,000-μsec delay has been achieved. The output also is linear over at least an 80-db range, while ripples in the passband and supernumerary reflections or signals can be kept down to levels of 60 db below the main delay. These properties, plus extreme stability and low temperature coefficient when a solid medium is used, make the ultrasonic delay line most useful when extreme fidelity of signal must be achieved.

The major disadvantages are (1) a high relative insertion loss, mainly due to the low efficiency of available transducers and (2) high cost, especially for the shorter delay times. The material for the larger sizes of fused quartz not only costs $90 to $160 per lb but must be ground with optical precision in a rather complicated manner.

Some *solid lines* are made of transparent materials that provide a variable delay by using a photoelastic pickup which detects the sound wave passing through. Certain designs use surface waves generated in solids; the pickup crystal or crystals can be adjusted to change their distance and delay time from the transmitter. In general, these variable delay lines do not have the bandwidth or freedom from distortion of the fixed types.

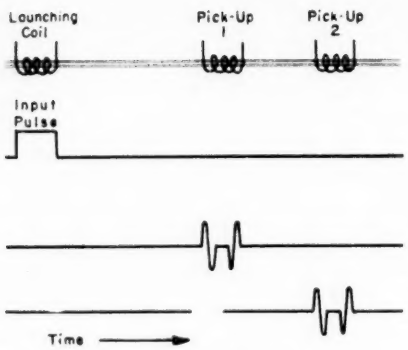


FIG. 4. MAGNETOSTRICTIVE DELAY LINE. Input pulse and delayed pickup-coil pulses are shown.

Liquid lines of mercury and water have been made but applications which require a variable delay are seldom used now.

Magnetostrictive Delay Lines

These resemble ultrasonic lines in that a mechanical wave is generated in a solid. The medium has to be ferromagnetic, with a large magnetostrictive coefficient for efficiency.

The transducers are compact coils of wire placed along the line (Fig. 4). When a signal current is applied, the magnetic field generated produces a mechanical distortion in the medium which is transmitted as a transient wave to the receiver. There the distortion of the medium changes the magnetic field and produces an electric current which is amplified and detected. Like ultrasonic transducers, the magnetostrictive ones differentiate the input signal and a carrier can be used to limit distortion of the signal envelope. However, because it is difficult to confine the magnetic field of the coils to less than one wavelength of the sound waves (approx. 0.020" at 10 Mc), and because ferromagnetic material absorb highly at megacycle frequencies, the use of a carrier is limited.

In many applications the medium is in the shape of fine wires to permit coiling into a compact shape. This introduces a change in velocity with frequency and further limits the bandwidth. In general a 2-5 Mc bandwidth, depending on the delay and distortion permissible, can be considered the upper limit.

A fixed magnetic field is usually applied to improve linearity of response because the magnetostrictive effect depends on the square of the field.

Magnetostrictive delay lines are coming into prominence because of ease of manufacture and of varying the delay. The latter only requires the addition of more pickup coils.

As magnetostrictive lines can be used best with a high-current low-impedance source, they are naturally associated with transistors and have many applications in the digital computer field. Crystal diodes are used to reshape the pulses.

Semiconductors

Any change in the relative energy status of a system produces a transient which takes time to travel from one point to another, introducing the possibility to use as a delay line. Heating a rod at one end and observing temperature fluctuations at the other is an example. In the same class of processes that have been considered seriously are the movements of ions in an electrolyte or a vacuum system, and the drift of minority carriers in an electric field in a semiconductor.

Unlike other situations, the drift delay time can be adjusted by varying the field and the velocities are lower by several orders of magnitude. Most of the work has been theoretical and the initial studies have indicated severe limitations. McCue[14] in a Lincoln Laboratory Report "Semi-Conductor Delay Lines," has developed equations for the delay and rise time that can be expected. At room temperature, independent of type of semiconductor, a delay of 10 μsec can be achieved with a rise time of 1 μsec; at lower temperatures both are shorter. This ratio depends only on the temperature and the potential difference through which the carriers drift.

Mechanical Delays—Tape Recorders

An analog equivalent of a delay line can be achieved by recording the signal on a tape or other device and reproducing the signal at some later time. While not strictly a delay line, this technique has many conveniences, such as controllable delay.

The bandwidth per tape is necessarily narrow but the input signal can be split in several bands and recorded on different tapes to be recombined later. The signal can be observed in real time if the pick-up head follows the input heads. With a closed loop system, erasing the signal allows continuous operation.

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APPLICATIONS OF DELAY LINES

DELAY LINES have many applications, as shown in the following table. For each application there will be found one type which may prove most satisfactory.

A. Timing Elements
1. Time Delays
2. Time and Range Markers
3. Frequency and Time Interval Generators
4. Navigation

B. Computers
1. High Speed, Multipurpose
2. Digital, Special Purpose
3. Analog

C. Radio and Radar
1. Moving Target Indicators
2. Integrators for Signal to Noise Improvement
3. Filters
4. Range Markers
5. Coding of Servomechanism Commands
6. Radar Target Simulators
7. Auto-Correlation Techniques
8. Television
9. Pulse Forming Networks
10. Compensation Networks for Multichannel Communication Systems

Timing Elements

In these applications, the major requirements are for an accurate, stable delay with a sharp rise time. Fidelity of input signal is not always required and often the fall time or subsequent signals are not important. Delay lines are used because these are more stable in these respects or less costly than other timing devices in the microsecond range.

1. Time Delays of various sorts are needed in many electronic circuits. The starting time for the sweep circuit of a CRT is a problem if the initial part of a signal is to be observed. The solution has often been to use a high-fidelity line to hold back the signal until the sweep has stabilized. In other instances the trigger for the sweep may be delayed by a lower quality line before being used to excite the signal source.

The simplest applications are to hold back one of two parallel channels until a transient condition in one or the other has died out. Where the parallel channels join at both ends, not necessarily in a feedback loop, the delay time in each channel inherent in the circuits also may have to be compensated for exactly.

2. Time and Range Markers. Delay lines offer a means for obtaining at least one fixed signal after a given event at little cost. Where the line has little loss or distortion, and is unterminated, a train of reflections may occur at fixed intervals from the initiating pulse (Fig. 1). These intervals are even or odd multiples of the delay time, depending on whether the input or other end is used as the output. Because of their greater bandwidth and freedom from distortion, ultrasonic delay lines are most commonly used for range markers.

3. Frequency and Time Interval Generators. By feeding the output from a delay line through an amplifier and reshaping circuit before putting it back into the delay line, a stable frequency generator is formed whose period is that of the delay in the line and circuits (Fig. 2). By using gates and coincidence circuits, this frequency may be counted down to lower values.

If different delay lines are used in cascade, or with taps in different positions, a wide range of frequencies

FIG. 1. TRAIN of reflections for range markers.

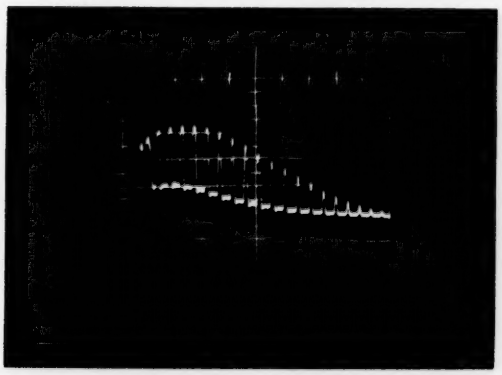
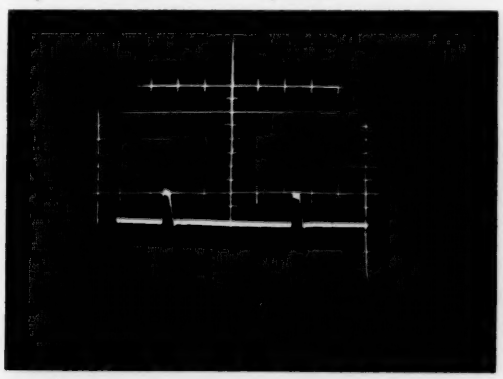


FIG. 2. PULSES from a frequency generator using a delay line to determine the period.



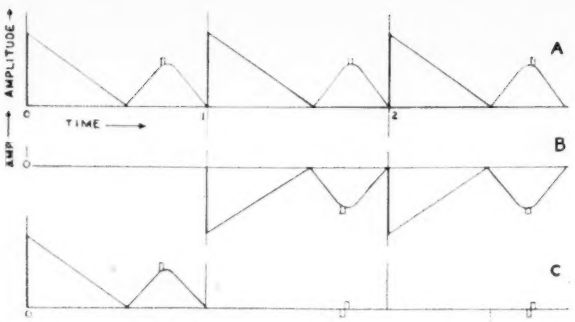


FIG. 3. PULSE SUBTRACTION in MTI. A shows radar return envelope from successive pulses; B shows delay returns with reversed phase; C shows residual signal A minus B.

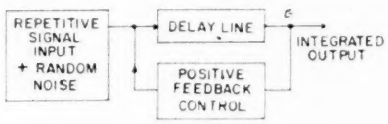


FIG. 4. INTEGRATION adds pulses.

and time intervals are available. These always will be locked together with respect to some initial time and be free of phase variations or drift in the electronic circuits.

4. Navigation Aids. At least one navigational system similar to Loran used delay lines in the millisecond range during World War II to aid in piloting by artificially extending the base line between two receiving stations. This system was known as H2X and used an ultrasonic line filled with water.

Computers

Computers were one of the original fields for which delay lines were specifically designed and had much to do with the development of the ultrasonic types.

1. High-Speed Multi-Purpose Digital Computers require a great deal of storage or memory capacity. If one considers the type of operation of a serial machine which performs such an operation as multiplication of numbers in succession, digit by digit, of the multiplier operating on the multiplicand, the need for storage is made clear. To take the product of 34 x 26, the machine multiplies 34 x 6 and gets a partial product of 204; then proceeds to multiply 34 x 20 to get the second partial product of 680. Before starting the second multiplication, the first product must be cleared from the multiplier and put in storage until the second is obtained. By converting the numbers into digital form and then into a train of pulses whose time interval is constant but whose amplitude is either 0 or 1, the numbers can be put into a delay line. The delay time is sufficient to allow the second multiplication to be performed. The two partial products are then added and the sum put back into the delay line if a third multiplication is to occur.

Even with parallel machines, temporary storage is often required for other operations; ultrasonic delay lines of several hundred microseconds with capacities of over 10 pulses per microsecond have been used.

At present, however, the newer computers are turning to other devices, such as ferrite cores, which have the advantage of a lower random access time, and a permanent storage. (If the power it cut off from a delay-line memory, the numbers are lost.) The shorter delay lines of the lumped-or distributed-constant type are still being used extensively in the switching, logic and coincidence circuits of the computers.

2. Digital Computers—Special Purpose. Many of the smaller computers designed to handle specific problems where the input rate, size of the numbers and the type of program to be run can be controlled closely, still find ultrasonic and magnetostrictive delay lines to be the most efficient. In these cases the random access time can be calculated and the delay line set to this value. The problems run are not so long that the possibility of a power failure is serious.

One of these machines in common use is the Hutchinson-Scarrott Pulse-Height Analyzer used in nuclear energy work; other machines of desk size are being developed.

3. Analog Computers have two types of needs for delay lines. The first is for synthesis of certain waveforms which can be generated by combining the proper delay lines; the second is to change the time scale at which the data are manipulated. The latter in particular will require a high-performance line with little distortion. For many of these purposes, variability by cascading or tapping is important.

Radio and Radar Applications

The various types of pulsed operation in radio and radar equipment led to the development of many forms of delay lines. In particular, radar has repeatedly emphasized the need for higher quality from the first days when delay lines were used mainly in the pulse-forming networks of the modulators.

1. Moving Target Indicators (MTI) provided the first need for ultrasonic delay lines and has since always stressed the dual requirements of long storage time and pulse reproducability.

The basis of performance for an MTI kit is the separation of small moving objects from a background of larger fixed objects by the relatively small shifts in phase and amplitude of the returned signal on successive pulse.

The process consists of storing a complete set of echoes from one pulse for a period between pulses and then subtracting this from the next pulse (Fig. 3). If conditions have not changed much due to various factors such as rotation of the antenna, all signals from fixed targets will have the same envelope at the same time and the successive pulses will cancel. In places where an object has moved radially with respect to the transmitter complete cancellation will not occur and a small residual signal will appear.

Working radar MTI's have cancellation ratios of over 40 db, which means that fixed targets can be reduced by a factor of 100 to 1.

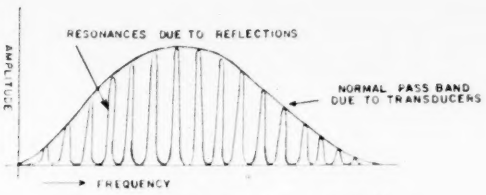


FIG. 5. **BANDPASS** of a "comb-filter"

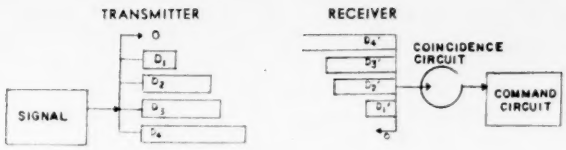


FIG. 6. **CODING** via delay lines.

2. Integration for Signal-to-Noise Improvement. By altering the MTI kit so that successive pulse trains add instead of cancelling, random fluctuations can be reduced in relative value. This process, known as *integration*, occurs, when the signal is of relatively constant phase and amplitude so that a series of M terms will have a sum of M times that of one (Fig. 4).

3. Filters. Since each delay line has a characteristic bandpass, it can act as a filter. When terminated properly, the filter will have the same band width for CW operation as for pulses. An unterminated delay line with strong reflections or one in a wide-band feedback loop will have many resonances in the passband that are spaced at harmonic intervals of the reciprocal of the delay time. When an observed signal has components at the corresponding harmonics, which occurs when the inter-pulse period equals the delay time for a long interval, the signal-to-noise ratio will be improved on passing through the delay line.

The process is that of integration where the signal components are stored and the random noise components discriminated against. The characteristic bandpass showing equally spaced, narrow peaks of equal amplitude is known as that of a "comb-filter" and has been made up of separate resonant circuits (Fig. 5). However, the delay lines can be arranged more effectively for the same purpose.

4. Auto-Correlation Techniques form a distinct application for improving the signal-to-noise ratio by using delay lines. The auto correlation function F (v) of a time-varying function E(t) is formed by taking:

$$F(v) = E(t)E(t + v)dt$$

where v takes on all values of t and represents a delay in the values of E(t) being multiplied. If E has any periodicities in (t), the only values of F(v) which will be non-zero, will be near corresponding values of v. In operating in real time, the incoming signals are fed into a delay line and tapped off at many points to form a continuous set of values of E(t + v). The time to reach a certain signal-to-noise level is the same as that for a single tuned high-Q circuit to respond to a weak signal, but the auto-correlation method has the advantage that it will respond equally well to all frequencies.

5. Coding of Servomechanism Commands. When pulses are to be sent over a communication link that is noisy or can be jammed, certainty of behavior can be increased by sending the command signals as a series of pulses with definite spacing. The receiver has a set of parallel delay lines corresponding to the spacing through which all the signals pass (Fig. 6). The output from the lines are fed to a set of coincidence circuits that will only trigger the final stage when all the delay line outputs have a signal at the same time. The probability of a wrong command being received is then reduced by the nth power of the probability of a single signal if n lines are used. Such a system takes more time to execute a command but requires less bandwidth than other redundant techniques.

6. Radar Target Simulators. One problem in training radar operators is that of duplicating the signals appearing on a CRT without making an airplane flight or a cruise at sea. By using an ultrasonic delay line, both fixed and moving targets can be made to appear realistically in the proper noise environment.

7. Range Markers. These have been discussed.

8. Television supplies many opportunities for the use of delay lines in timing, pulse shaping, and rearranging of pulses. There is one unique application which has not yet been fully applied. This is the reduction of bandwidth needed at present to carry a clear picture. A present about 4-Mc video bandwidth is needed to change from completely black to white in the time taken by the scanning spot to move its own diameter. This is the maximum rate of change but is seldom required since actual changes in light intensity are usually more gradual, not only from spot to spot, but from line to line and to some extent from frame to frame. By storing the signals in a delay line and comparing them with corresponding values in nearby locations somewhat as is done in radar MTI work, only the differences are retained. The small differentials are used to modulate the carrier in a narrow frequency range and at the receiver, a similar delay line system with integrating circuits is used to reconstitute the signal to its original values.

9. Pulse-Forming Networks. These come in many sizes and power ranges A current source E is used to charge capacitors, which are discharged through the delay line. The pulse shape is the result of proper design, and the number of sections will vary with the pulse length, rise time, and flatness desired.

10. Compensation Networks for Multichannel Communications Systems. These include the oldest applications of delay lines and were first introduced to correct for phase shifts with frequency in transmission lines. Their need is still present in instances such as transcontinental transmission of television where the video and audio signals may be sent over different links and have different delays. Compensation delays are added to restore time coincidence of the received signals.

HOW TO BUY A DELAY LINE

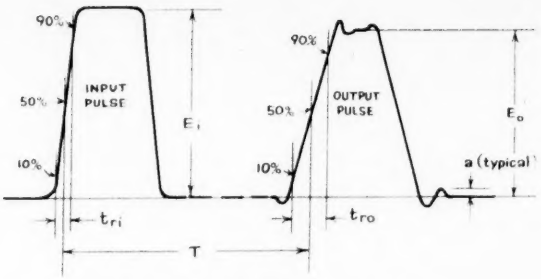


FIG. 1. TYPICAL input and output waveforms.

Delay time, rise time, impedance, distortion and attenuation are the basic delay-line characteristics. Here are definitions of these terms, feasible limits, and the other factors the buyer should know and include in his delay-line specifications.

RODERICK YARD
ESC Corporation

WHEN ORDERING a delay line, the engineer should provide all available information as to the characteristics of the signal to be transmitted, such as the delay time, rise time, characteristic impedance, distortion, and attenuation (see Fig. 1). Packaging requirements, temperature ranges for operation, and required environmental conditions should also be specified.

Delay Time

Delay time is the elapsed time between the 50% amplitude point of the input-pulse leading edge and 50% amplitude point of the output-pulse leading edge. These points can be determined relatively accurately on the pulse and, therefore, the time delay can be measured more accurately at these points than at other points.

The time delay determines the length of time information can be stored. It determines when coincidence shall take place or, in the case of a pulse-generating circuit, the width and characteristics of the pulse formed.

Tolerance

It is common practice to manufacture delay lines with a 5% tolerance, but units can be manufactured with tolerances of 1% or, depending on the delay, as small as 0.01 μsec absolute delay accuracy. These measurements are reliable only when the point on the leading edge of the input and the leading edge of the output pulse can be determined accurately.

Many engineers specify a large number of taps in an attempt to solve a tolerance problem, or when the exact delay is not known. While this is satisfactory for laboratory application, the unit often goes into production with these taps, raising its price.

Rise Time

The rise time of a delay line is generally defined as the elapsed time between the 10% and 90% amplitude level of the *leading edge of the output pulse*, assuming a step function input.

Where the input pulse has a finite rise time, a *network rise time* can be expressed as follows: Rise time of the network is equal to the square root of the square of the output-pulse rise time minus the square of the input-pulse rise time:

$$t_r^2 = t_{ro}^2 - t_{ri}^2$$

Rise time is another way of expressing *bandwidth* of the delay time. Delay-line bandwidth (in megacycles) is equal to 0.36 divided by the rise time (μsec):

$$BW\ (Mc) = 0.36/t_r\ (\mu sec)$$

This gives the approximate 3-db bandwidth of the delay line.

The bandwidth of the delay line determines the fidelity with which it reproduces a given input. If all of the frequency components of the input pulse or input signal are within the passband of the delay line, the output is a high-fidelity reproduction of the input.

Rise time is perhaps the most abused specification that the component engineer determines. A component engineer often will overspecify his rise time not realizing that this is the major source of difficulty encountered in the manufacture of delay lines.

Rise time also can be measured as the slope of a line passing through the 50% point. This introduces certain difficulties, however, in the event of distortion in the pulse. It is possible for such a slope measurement not to be indicative of the pulse rise time or bandwidth of the delay line but, rather, of a small portion of the pulse.

Until recently most available delay lines had achievable rise times in the order of 3% of the time delay. This means that for a 10.0-μsec delay line the best practical rise time achievable would be 0.3 μsec. Owing to limitations placed by capacitors and coils, a bandwidth in the order of 30 to 40 Mc is the most that can be obtained in lumped-constant lines; bandwidths of greater than 40 Mc usually require delay-cable techniques. Such techniques result in extremely large bandwidth, but are inefficient in terms of volume. (ESC Corporation has recently completed a successful development of a delay line whose time-delay/

rise-time ratio is in the order of 145:1; while this development represents the limit of the state of the art at present, it does not preclude the possibility of designing delay lines with even greater time delay/rise-time ratios, but at large expense.)

It is to the system engineer's advantage if he can reduce his rise time or bandwidth requirement to a minimum because every bit of reduction saves considerable money. He also improves the ability of the delay line manufacturer to deliver him a delay line which is more realiable than one with an extremely high delay-time/rise time ratio.

Generally it is better to specify the rise time of the delay line rather than the bandwidth. If only bandwidth is specified, then the only point that has been specified is that of amplitude response. The rise-time specification, moreover, is easier to measure than that of bandwidth because bandwidth data can be confused by mismatch of the delay line or by minor reflections.

Characteristic Impedance

Characteristic impedance of the delay line is that value of terminating resistance which provides minimum reflection to the input of the network. It is not a difficult specification to meet and generally does not require tight tolerances.

Transmission-line theory shows that a line which is terminated in impedance much higher than its characteristic impedance can be made to show an apparent amplitude gain, while a delay line which is mismatched into a low impedance will show increased attenuation.

Terminating a delay line with a pure resistance does not match the delay line optimally for all frequencies because a delay line will appear inductive or capacitive at certain frequencies, depending on the design of the network. For extreme applications it is thus necessary to terminate in a complex RCL network. However, for most applications the delay line can be terminated in a pure resistance which is considered its characteristic impedance.

During testing the input is observed to make sure that there are no reflections above a certain agreed amount due to mismatch.

Impedance has little effect on the price of a network, but it does have considerable effect on the volume; the higher the impedance, the larger the coils must be for a given network. Coils are volumetrically much less efficient than capacitors and, therefore, for a given time delay a 2000-ohm network generally will occupy more volume than will a 500-ohm or 1000-ohm network.

The impedance tolerance should be looser than that for the delay time. Tight tolerances on both delay time and characteristic impedance result in very expensive units.

Many engineers forget that delay lines should be terminated in a characteristic impedance at both the input and output of the unit. This is necessary so that any discontinuities and reflections which occur along the line and which are transmitted to both the input and the output are not reflected again to increase the apparent amplitude of distortion.

Distortion

Any mismatch results in distortion. Distortion is expressed generally in percent and is equal to the peak amplitude of the distortion divided by the input amplitude (or the amplitude of the pulse at the point under consideration) times 100. Referring to Fig. 1:

$$\% \text{ Distortion} = (a/E_o)\ 100$$

Distortion consists of two types—(1) that due to discontinuity along the delay line and (2) that due to ringing of various components within the line. Ringing distortion exhibits the typical characteristics of an overdamped circuit. Discontinuities exhibit short, sharp spikes, resembling noise to the point where many engineers refer to the noise level of the delay line rather than to the distortion figure.

In addition to amplitude distortion there is also *phase distortion* (nonlinear delay of the various frequency components of a pulse or signal sent through the delay line). If there are different time delays for the various frequency components of the pulse, there will be a shift in the pre-emphasis (anticipating signal) of the pulse. It is generally easiest and most convenient to measure the phase distortion in terms of pre-emphasis. If pre-emphasis is excessive, the pulse will not come up to 100% amplitude within the fastest possible time.

Generally it is possible to achieve delay lines which have approximately 10% distortion assuming a step-function input. However, distortions as low as 1% can be achieved when using a pulse or signal whose highest frequency components are much less than those present in the network bandwidth. Here the bandwidth is larger than that required for the transmission of the pulse; this additional bandwidth is the price one must pay for reduced distortion.

Distortion on the output pulse also is a function of the input rise time: the faster the input rise time, the greater the possible distortion. In delay lines with high attenuation ratios the apparent distortion is less because the reflection is rapidly attenuated.

Attenuation

Attenuation is the difference in amplitude between the input and output pulse when the network is terminated in its characteristic resistance. The attenuation in db is:

$$\text{Atten (db)} = 20 \log_{10} E_o/E_i$$

Other Factors

A systems engineer who maintains the maximum possible tolerances on delay time and characteristic impedance, who permits his rise time to be the maximum possible, and who has kept his attenuation and distortion to the largest possible figure, has specified a delay line which can be most economical to build.

He should also specify any limiting mechanical or environment characteristics—size, weight, working voltage, operating temperature range, maximum storage temperature, and environmental conditions under which the delay line must operate. If he contacts his sources as soon as his problem comes up, user and manufacturer can work together to achieve a unit which will satisfy all requirements.

TABLE 1. MEASURED DELAYS OF NOMINAL 7.05-USEC AND 10.05-USEC DELAY LINES

Date	7.050 USEC. STD.	10.050 USEC. STD.
3/12/57	7.049	10.046
3/13/57	7.056	10.055
3/14/57	7.058	10.052
3/14/57	7.053	10.052
3/18/57	7.054	10.052
3/18/57	7.052	10.053
3/18/57	7.053	10.052
4/24/57	7.056	10.045
6/11/57	7.058	10.048
9/ 5/57	7.054	10.048
11/14/57	7.058	10.047

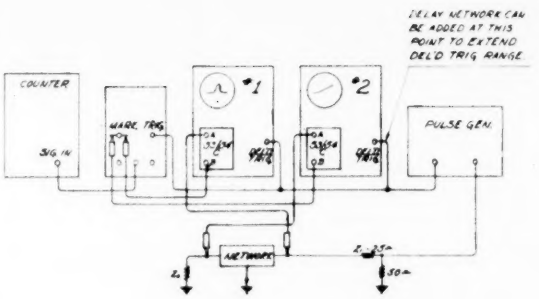


FIG. 1. TIME-INTERVAL measurement set-up. Counter is Hewlett-Packard HP 524B or equivalent; marker trigger is Tektronix 180S1 or equivalent; scopes are Tektronix 545 or equivalent; pulse generator is Hewlett-Packard 212A or equivalent; regulator is General Radio 1570AL or equivalent;

Time Interval Measurement

This technique for measuring up to 20-usec time intervals to 0.01 usec involves the successive counting of 1-, 5-, 10-, and 50-Mc markers.

DELAY LINE TESTING requires accurate measurement of time intervals to 10^{-8} second. The desired accuracy was ± 0.010 μsec in the range of 10 to 20 μsec. This is a percentage tolerance on the order of $\pm 0.06\%$.

Actual measurements using delay lines over a period of approximately one year are represented in Table 1. (Several different individuals made the readings with considerable interchange of equipment from date to date.) It appears that repeatability is better than ± 0.005 μsec (this includes any variation in the units being measured). Correlation with other laboratories using different systems indicates there is some discrepancy other than repeatability, but the reason has never been discovered. The correlation error is approximately ± 0.015 μsec, but still leaves a total error figure of about 0.1% maximum.

Instrumentation

The set-up shown in Fig. 1 is the one used to measure delay lines. The counter provides a running check on the crystal frequency of the marker trigger unit. The marker unit is used to trigger both scopes and the pulse generator, and to provide all markers used for measurement.

Scope 1 monitors the input pulse with respect to zero time reference. This is necessary due to both the displacement of markers within the marker unit (see Fig. 2) and drift in the trigger circuit with respect to the input pulse. Drift of the 50-Mc markers with respect to the A trace appears to be simultaneous on both scopes, but is relatively slow and can be corrected by horizontal positioning at the time of the reading. Drift of the pulse-generator circuit with respect to the marker trigger can amount to ½ cm. This is also a slow drift and may be corrected at the time of the reading. Scope 2 presents the output of the network being measured. The voltage regulator improved drift characteristics.

Measurement Technique

Fig. 3 shows the successive steps in a typical measurement of 11.307 μsec. Using 1-μsec markers, position the desired zero time reference (in this case the 50% point of the leading edge of the input pulse) approximately in the center of scope 1. Momentarily place the probe of scope 2 at the same point as the probe on scope 1 (input to delay line) and adjust the

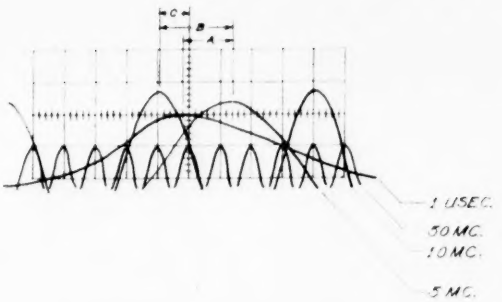


FIG. 2. DISPLACEMENT OF 1-Mc, 5-Mc, 10-Mc and 50-Mc markers in marker trigger unit. Scope sweep is 0.02 usec/cm. A is displacement between 1 usec and 5 usec markers; B is displacement between 5 and 10 Mc marker; C is displacement between 10 and 50 Mc markers.

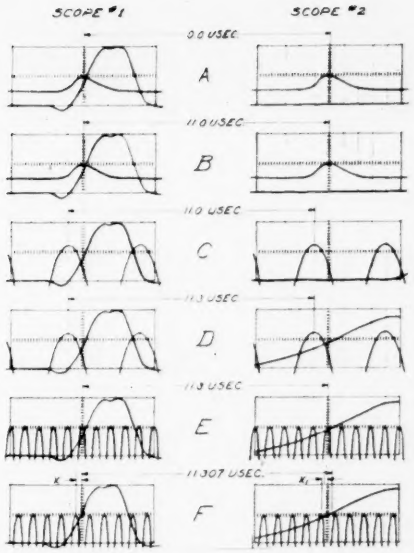


FIG. 3. MEASUREMENT OF 11.307-usec delay. A and B show 1-usec markers; C and D show 0.1-usec markers; E and F show 0.02-usec markers.

To 10^{-8} Second

RODERICK A. BREW

Richard D. Brew and Co., Inc.

delayed sweep so that the same 1-μsec marker appears on both scopes, as in A of Fig. 3.

Replace the probe from scope 2 on the output of the delay line. Vary the delay time multiplier slowly, counting the 1-μsec markers until the 11-μsec marker preceding the output signal is in the same relative position on scope 2 as the zero reference 1-μsec marker appears on scope 1 (see B).

Switch the marker generator to 0.1-μsec markers as shown in C. It is not necessary to re-adjust the horizontal position to center the markers—only be sure that the relative position does not change. Vary the delay time multiplier slowly, counting 0.1-μsec markers, until the 11.3-μsec marker preceding the output signal is in the same relative position on scope 2 as the zero reference 0.1-μsec marker appears on scope 1 (see D).

Switch the marker generator to 0.02-μsec (50-Mc) markers as shown in E. The horizontal position of scope 1 should now be adjusted so that the desired zero reference on the trace will be centered on the scope. The 0.020-μsec marker which previously represented the zero reference will now have shifted to the right or left (see F). Shift the corresponding marker on scope 2 a like amount.

Now, depending on the 50-Mc marker accuracy, the center of the grids on scope 2 should represent 11.300 μsec. The additional difference between this point and the actual point on the trace to be measured should give the final reading of the desired time interval. Note that although it is possible to work on either the extreme right or left-hand of the grid for final measurement, it is best to stay within the limits on the center two centimeters and avoid errors due to parallax and nonlinearity in the sweep speed. It is also necessary, when making the final reading, to check the zero reference for shift.

Errors

The errors in such a measurement are limited to operator ability, the accuracy of the 50-Mc marker, and any possible displacement between trace A and B within the scope due to the delayed trigger circuit. Other points which may be useful in making measurements with the described set-up are:

1. Momentarily shift sweep to 1 μsec just before reading to make sure vertical positioning has not changed the 0 and 100% vertical reference on the scope.

2. Switch off the 50-Mc markers at the instant of reading because some feed-through of the marker pulse on probe B to probe A may change the wave shape present on A. (Use probes on the 50-Mc marker connection to the marker trigger.)

3. If in doubt of the measurement (errors are usually an even 0.020 μsec as a result of picking the wrong marker), reverse the procedure and count back to zero reference.

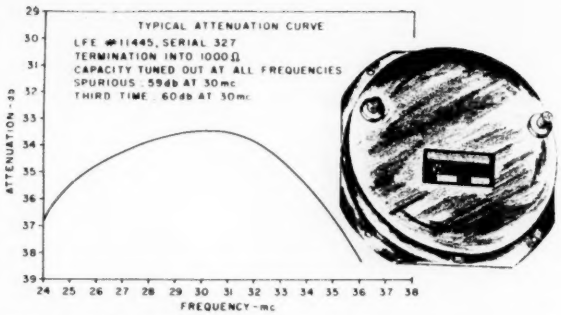

TYPICAL ATTENUATION CURVE
LFE #11445, SERIAL 327
TERMINATION INTO 1000Ω
CAPACITY TUNED OUT AT ALL FREQUENCIES
SPURIOUS - 59db AT 30mc
THIRD TIME - 60db AT 30mc
ATTENUATION - db
FREQUENCY - mc

FIG. 1. QUARTZ delay line with operating frequency of 30± 1 Mc at room temperature, bandwidth of 10 Mc, delay time of 500 ± 1 usec at 20°C.

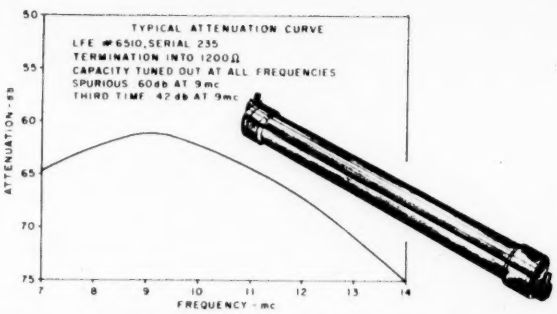

TYPICAL ATTENUATION CURVE
LFE #6510, SERIAL 235
TERMINATION INTO 1200Ω
CAPACITY TUNED OUT AT ALL FREQUENCIES
SPURIOUS - 60db AT 9mc
THIRD TIME - 42db AT 9mc
ATTENUATION - db
FREQUENCY - mc

FIG. 2. MERCURY delay line with operating frequency of 9 Mc, bandwidth of 3.2 Mc, and delay time of 2778 ± 25 usec at 20°C.

RECENT DELAY-LINE APPLICATIONS

HARRY H. LOCKHART

Laboratory for Electronics, Inc.

Computer Use

MERCURY DELAY LINES were used extensively in the early 1950's in the high-speed large-scale general-purpose computers such as Univac 1, SEAC, and the English EDVAC. Several descendants of the SEAC, such as MIDAC and FLAC, also used the mercury delay line. These machines generally used several banks of lines using several hundred bits at a 1-Mc bit rate.

Since that time use of the mercury delay line for high-speed internal storage in computers has generally disappeared in new designs (quartz delay lines were never used except in a few isolated cases). The techniques which displaced mercury delay lines are those using magnetic-core matrix storage and magnetostriction delay lines. These latter units are acoustic delay lines which do not use a carrier and are not suitable above a 1-Mc bit rate.

Computer bit rates are now increasing to the 5-10 Mc range in some applications. There appears to be good reason to believe that quartz delay lines may become a suitable storage device at these higher bit rates. For certain applications in digital computers, the quartz delay line can be used without a carrier, thus making it competitive price-wise when delay accuracy is imporant.

MTI Use

An airborne radar set recently was modified by adding an MTI channel. In this system, unipolar video is applied to a modulator where it is used to frequency-modulate a 15-Mc carrier frequency which is then frequency doubled. Cancellation of fixed targets and detection of moving target is accomplished by delaying the return signal for a time equal to one repetition interval and then comparing it with the return signal associated with the subsequent period. The quartz delay line used operates at 30 Mc and has a delay time of 500 microseconds (Fig. 1). The actual comparing of the two signals takes place in a type 6BN6 phase detector.

Mercury delay lines (Fig. 2) also have been and still are used extensively for MTI operation.

Locktest and Range Marker Use

Another use of an ultrasonic line is for the generation of locktest pulses that are used as an artifical signal, in place of actual target video, for testing the system. In this application the delay line is used in a Locktest Amplifier. From a mixer, this assembly receives the transmitted pulse which is used to drive a delay line. The ultrasonic energy in the delay line is reflected back and forth between the input and output transducers, and the input transducer produces a train of r-f pulses a few microseconds wide.

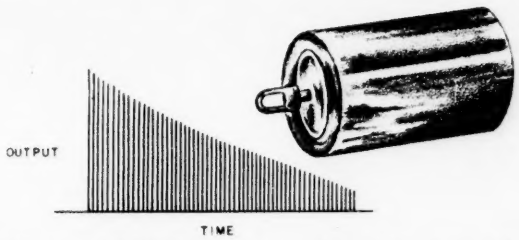


FIG. 3. PRECISION range marker delay line with operating frequency of 30 Mc, bandwidth of 7 Mc, and signals separated by 6.1 usec (delay time is 3.05 usec).

The precise interval between the locktest pulses allows for their use in calibrating the system indicator range marks. Many lines are built exclusively for range mark use, such as 1000 yds, 2000 yds, 5 nautical miles, etc. (Fig. 3).

Recirculating Use

In a radar test set recently developed, delay lines are used to generate a series of simulated echo pulses. The r-f signal from the system under test beats with a stalo, and the resultant i-f signal drives the delay line. The amplifier following the delay line feeds back a portion of the delayed signal to the i-f amplifier that drives the delay line. The output of this circuit is then a series of pulses which may be processed to simulate targets that are fixed, moving, or moving superimposed on fixed targets. By using lines having different delay times the interval between the simulated returns can be varied.

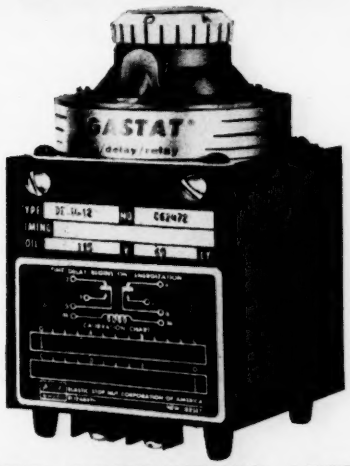
Staggered PRF Use

Ultrasonic delay lines have been used in a staggering switch circuit to establish a staggered PRF to alter the first blind speed of a radar set. A circulating trigger, generated in the basic timing unit of the system, is fed to a staggering switch circuit every 400 microseconds (let us say). It is used to amplitude modulate a 60-Mc carrier prior to being passed through a delayed or undelayed channel, depending on the state of a channel switch tube. After the first circulating trigger is sent through the undelayed channel of the staggering circuit, the electronic switch is moved to the delayed position. This causes the next circulating trigger to be applied through a 100-microsecond delay line of the delay channel. After this second circulating trigger, the switch is moved back to the undelayed position and the process is repeated. In this way the staggered PRF trigger is generated, occurring alternately at 300 and 500 microseconds.

Dual Frequency Use

Other lines perform a dual function. One such line, operating at 60 Mc, functioned in the delayed channel of a comparison circuit which distinguished moving targets from fixed targets. The same delay line also operated at 20 Mc in a video integration circuit which eliminated wildcatting from the system video display.

NEW AGASTAT®



HAS LONGER OPERATING LIFE

The Agastat time/delay/relay has been completely re-designed, inside and out, to make every moving part last longer and operate more reliably.

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Journal of the S C M A . . .

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COMPUTER-CONTROLLED PILOT PLANT

An Automatic Pilot Plant, called a MicroPlant, is programmed for continuous composition analysis, data logging, scanning, computing, or closed-loop operation with data as the product. Here is a systems engineering approach to the automatic pilot plant.

J. K. WALKER
C. K. HINES

Systems Division
Consolidated Electrodynamics Corp.

COMPUTER-CONTROLLED and built to scale, an automatic pilot plant can supply data for studying new design concepts, for getting commercial units into operation ahead of schedule, and for obtaining control criteria. This "MicroPlant" can be programmed for continuous composition analysis, data logging, scanning, computing or closed-loop operation, with data as the product. As a process-development facility, it combines the best efforts of mechanical, electronic, instrument and chemical engineers in a system engineering approach to pilot-plant design and instrumentation. A typical system is designed to study catalyst aging, reforming, hydroforming, and catalytic cracking or similar chemical and petro-chemical processes. The auto-plant may also be used as an adjunct to studies of process frequency response, instrument evaluation, controller location, etc. It was designed for Esso Research and Engineering Co.

Small enough to fit in the average office, the automatic pilot-plant is of modular design and consists of three separate units—utility, reactor, and product stabilizer (distillation).

The *utility unit* contains supply lines for gases, liquids, and power with their related valves, transducers, metering pumps, and controllers. The *reactor* section consists of a pre-heater, reactor, and distributing valves with a recycle compressor and temperature, pressure, gravity, and recycle controls.

The *product recovery* system consists of a stabilizer (distillation unit), for the separation of the gaseous (C_4—C_5 split) and liquid products. This unit contains multiple feed points, gas and liquid product collection systems, liquid-level and product-weight measurement. An integrated refrigeration system is used to control the stabilizer operation. All plumbing and inter-connecting hardware can easily be broken between units to permit substitution of various reactor, utility, and recovery designs.

November Meeting: Thursday, the 20th California Country Club, Whittier, California.
Feature: Mr. Otto Kneisel of Hammel-Dahl Division of General Controls Co. will discuss Selecting and Sizing Control Valves.

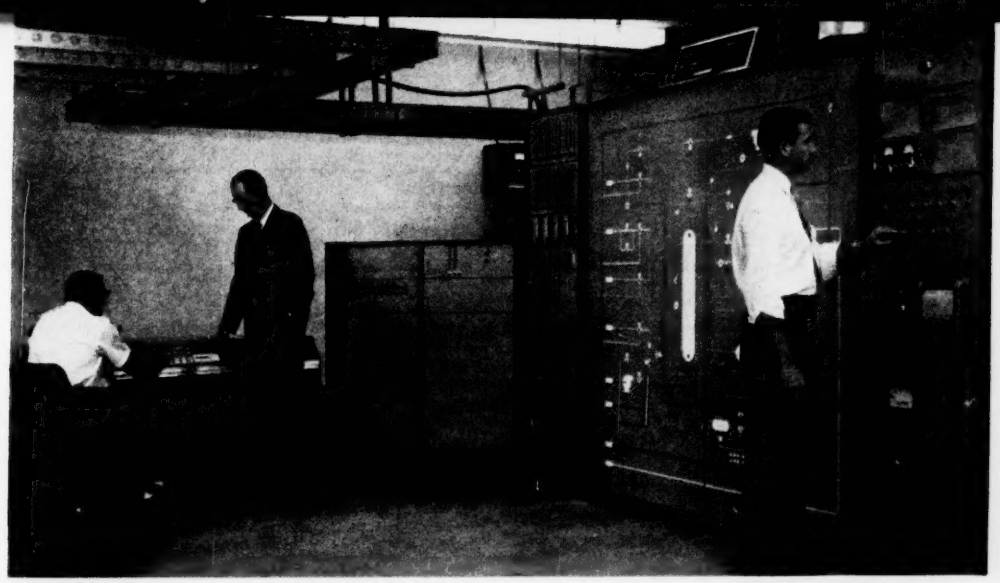
Graphic Panel and Control Instruments

The control and analytical instrumentation is located in a separate unit behind doors imprinted with a graphic description of the system operation. Electronic controllers are used throughout for temperature, pressure, differential-pressure, flow, liquid-level and weight measurement. Continuous composition analyzers are incorporated for end-point control and data correlation (such as octane number).

During the reaction cycle, hydrogen, gravity, gas and liquid products are analyzed. During the catalyst regeneration cycle, oxygen, moisture, and carbon dioxide are used to control catalyst regeneration and to account for carbon deposits in the material balance. Vapor-liquid chromatography is being used primarily for gas and liquid product analysis. Various other specific and non-specific analyzers are equally applicable for this and similar applications (mass spectrometers, infrared, refractive index, etc.).

Composition Analysis

Since all processes involve compositional changes, the fundamental variable is chemical composition as a function of the plant operating variables. When continuous analysis of the product is performed, the over-all efficiency of operation and accuracy of data are greatly improved. This is accomplished by reducing the size of the sample required for analysis and empirical testing, by reducing the time presently required to transport these samples to and from the laboratory, and by avoiding the hazards of representative sampling on a "batch basis." In many cases it is impossible to take a sample without significant change in composition (for example, H_2S and water,



MICROPLANT uses a Royal-McBee LGP-30 computer and Swartwout electronic control system. Consolidated Electrodynamics Corporation supplied water analyzer, vapor-liquid process chromatography, hydrogen and oxygen analyzers, product weighing system, and logger-scanner. Mine Safety Appliance Company's infrared analyzer is used for CO_2. Fielden supplied the liquid level control system and West Instruments supplied the magnetic amplifiers.

HCl and H_2O). Continuous sampling directly into an analyzer often provides the answers to this problem.

The MicroPlant presently includes a differential thermal-conductiviy cell for hydrogen analysis, infrared for carbon dioxide, an electrolytic moisture analyzer, paramagnetic oxygen analyzer, and two multiple-column chromatographs for gas and liquid product analysis. Octane correlations with VLPC, refractive index, dielectric constant, and mass spectrum have been demonstrated.

Logging and Scanning

The logging functions of the data-acquisition system are used to feed operating data to a digital computer prior to tabulation. All computing functions are eliminated from the basic analog-to-digital conversion equipment for simplicity and long-life reliability.

Computer

To supersede the necessity for data transmission to a central computing service and its attendant scheduling problems, a small general-purpose digital computer is incorporated into the system. All functions of computing are reserved for this unit. The computer offers sufficient storage capacity to continuously integrate and treat the data "in process." All functions of averaging, square root, and material balance computations are reserved for the readout cycle. Having surveyed the limits of operation of such units for any one condition of charge, catalyst, etc., optimization programs based on chemical composition are scheduled. The computer is used with the scanner to determine system or plant equilibrium and thereby effect tabulation or scheduling changes in the operating variables. The computer as such does not perform any direct control function upon the plant; the controller set-point is changed by the computer through a numerical programming unit. Data may be acquired in buffer storage (tape) prior to computer use.

Programmer

The programmer includes automatic leak testing, reaction and catalyst regeneration cycles. Linking the computer to the controllers, a digital setpoint storage function is served by the programmer. It is possible to make a balanced change in all set points either (1) manually, (2) automatically or a pre-arranged time schedule, or (3) upon reaching plant equilibrium as determined in the computer. Most large evaluation tests are internally programmed for unattended operation.

Operation

With a MicroPlant facility available for process design studies, it is possible to operate (1) manually, (2) with internal time programming, (3) on the basis of equilibrium conditions, or (4) for optimal composition analysis.

Promoting long-range planning of design studies, the plant, with its integrated data handling and continuous analyses, can be programmed to run under essentially optimum conditions of octane number of the product during the reactor cycle. When the economics of conversion rate versus temperature of reaction so indicate, the catalyst is regenerated—but only for a minimum length of time based upon the oxygen and carbon dioxide content of the flue gas. Other functions of the operation, such as inert gas purge, leak test, and plant shut-down are automatically programmed in their logical order.

System Use

In addition to establishing the criteria and instrumentation for automatic process control at the source of the data, there are many justifications for the pilot-plant facility. The modular design concept of the plant adds versatility to the range of variables studied in any one unit. The around-the-clock operation increases the number of runs per day from the usual four hours to six times that capacity.

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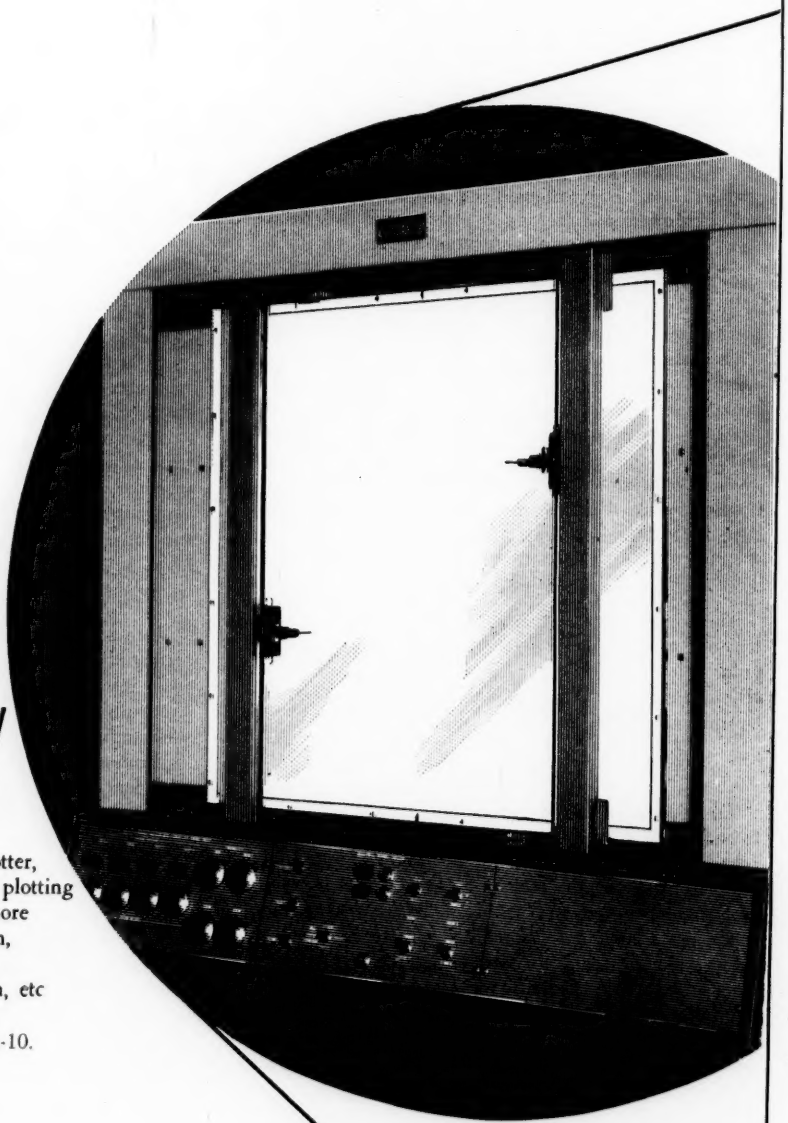

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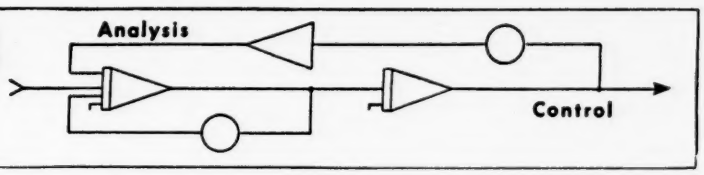
The SIMULATION COUNCIL Newsletter



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Bits

This month we have, under Pieces, *Jerry Kennedy's* somewhat edited notes on the June meeting of the Midwestern Simulation Council, at which "Cute Tricks in Simulation" were discussed. Presentations were "Novel Analog Circuits" by *Charles Walli*; "Relay-Type Transport Delay Simulator" by *Lambert Haner*; "Pneumatic Power Positioner Simulation" by *G. Rouvalis*; "Logical Circuit Elements" by *Jerry Kennedy*; "Friction and Switching Circuits" by *P. J. Hermann*; and "Frequency Response Measurements with an Electronic Analog Computer" by *Vern Larrowe*.

Under Info we have some comments on the purpose and operation of the Simulation Councils, and we close with a "Thot," not profound.

Pieces

MIDWESTERN S/C MEETING OF 9 JUNE ON "CUTE TRICKS IN SIMULATION"

J. B. Clymer represented North American Aviation when that company was host to the Midwestern Simulation Council meeting at Columbus, Ohio on June 9th this year. Sixty-six representatives of 33 organizations met to discuss "Cute Tricks in Simulation" and to inspect some of the NAA computing facilities.

Walli on Novel Circuits

Chuck Walli (NAA, Columbus, Ohio) discussed "Novel Analog Circuits" which use high-gain dc amplifiers, RC networks, and crystal diodes. He sketched limiting, absolute value, structural damping, and hysteresis circuits on the blackboard, and anyone interested in these circuits should contact Chuck—with our best wishes. Jerry Kennedy says he tried unsuccessfully to get copies from Chuck for three months!

Haner on Delay Simulator

Lambert Haner (Thompson Products, Cleveland, Ohio) gave a fine paper entitled "Relay-Type Transport Delay Simulator" which described a technique for simulating dead-time or transport delay. This they accomplish by using a relay type of sampler circuit driven by variable-speed flip-flops. The sampled input is stored on capacitors and picked off at a controlled time later on. Each channel uses 8 capacitors and 4 telephone-type relays. The sampling rate is 38 per cycle. Control of the flip-flops permits variation of the delay time. A dual-channel model cost Thompson Products $550.00. Since relays rather than stepper-switches are used, the device can act as a multiplexer, and can simulate a sampled-data system.

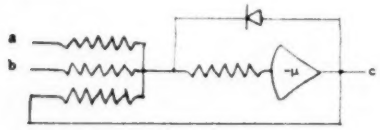
Rouvalis on Positioner Simulation

G. Rouvalis (Hagan Corp., Orville, Ohio) gave the next talk, on "Pneumatic Power Positioner Simulation." The Hagan Corporation manufactures power positioners which use a spool type of pilot valve to control the pressures to cylinder and piston actuators. In simulating this type of power positioner, they had to represent mass flows as a function of cylinder pressure and pilot valve position. The original attempt showed that about six non-linear equations with some complicated switching circuits would be required. However, they didn't have enough computing equipment, so it was necessary to simplify the simulation and use a minimum amount of non-linear equipment. They found that when a mass flow correction factor equal to the product of the area of the valve and the difference between the cylinder pressure and some constant was used, a reasonable approximation to the actual valve characteristics was achieved

and used less equipment than originally expected. The system proved quite satisfactory, very stable, and plots were shown which illustrated the closeness of the approximation.

Kennedy on Logical Circuit Elements

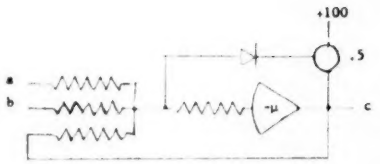
Jerry Kennedy (Electronic Associates, Long Branch, N. J.), speaking on "Logical Circuit Elements," discussed the use of general-purpose analog-computer components in simulating them. The logical elements are required to simulate various interlock systems in a chemical or petroleum process, and can also be used to introduce decision functions into a process. Another area in which they are useful is in scheduling problems where it may be necessary to simulate dynamics and decision systems, and to use the computer to evaluate the results of a variety of different schedules. Jerry told about four basic circuits which have been used in connection with work done at EAI's Princeton Computation Center.



If	Then
a = 1, b = 1	c = 1
a = 0, b = 0	c = 0
a = 1, b = 0	c = 0
a = 0, b = 1	c = 0

FIG. 1

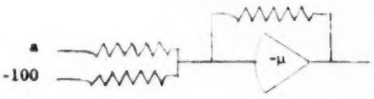
Figure 1 shows an AND circuit and the attendant mathematics. Here the "1" is actually +100 volts at the input, −100 volts at output. This circuit can be extended to N inputs by adding additional one-meg summing resistors, and making the feedback resistor equal to $1/(N-1)$ meg. In checking the circuit on the computer for N=6, they found that the output remained below 0.6 volt for 5 inputs or less. With all 6 inputs the output became −100 volts, exactly as would be expected. The sensitivity of the output to the magnitude of the last input was 1. This sensitivity could be increased by using a high-gain connection and introducing a slight additional bias beside the −100 volts. This bias would be required so that the amplifier would not drift to −100 volts when all but one of the inputs were +100 volts.



If	Then
a = 1, b = 0	c = 1
a = 0, b = 1	c = 1
a = 1, b = 1	c = 1
a = 0, b = 0	c = 0

FIG. 2

Figure 2 shows the necessary circuit for an OR circuit. This also can be extended to N inputs by adding additional summing resistors. If any input A to N is not 0, then C is 1. If A to N are 0, then C is equal to 0.



If	Then
a = 1	c = 0
a = 0	c = 1

FIG. 3

Figure 3 is a Not circuit which is self-explanatory.

Finally, Figure 4 shows the Gate circuit. One problem with this circuit is that in the cutoff region the output may not be exactly zero because the output of the first amplifier is driven. Minus quantities can be handled provided all are consistent and the diodes are properly oriented. If you start changing signs you may use too many inverters.

Hermann on Friction and Switching

P. J. Hermann (Goodyear Aircraft Corp., Akron, Ohio) gave a double-barrelled talk, "Friction and Switching Circuits," the first shot being on the friction circuits. This is a natural problem at Goodyear; the rubber people are vitally concerned with friction characteristics of tires and surfaces. Fig 5 shows the conventional dry-friction simulation in which the friction force is in one direction or another at a constant value depending on the direction of motion. P. J. theorized that this is not ideal in that static friction is greater than dynamic friction. The necessary graph shows the $\mu_s N$ is larger than the dynamic friction force $\mu_k N$. As the velocity term passes through zero, the static friction rises to a maximum value and then decreases slowly to a stable value of $\mu_k N$; however, when the $\dot{x}$ term is decreased from some maximum value, P. J. believes that the friction force returns to the ordinate in a straight line and does not follow the original slope between the $\mu_s N$ and the $\mu_k N$ values. This is very difficult to obtain, and he has tried many different techniques to achieve this characteristic.

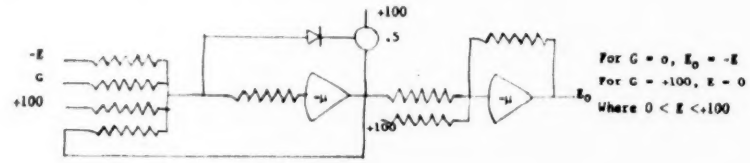


FIG. 4

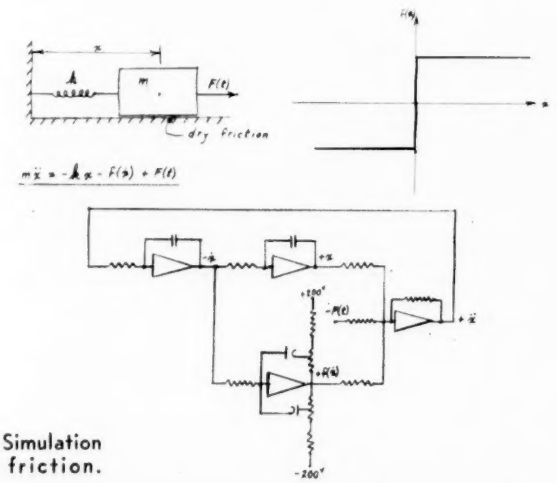


FIG. 5. Simulation of dry friction.

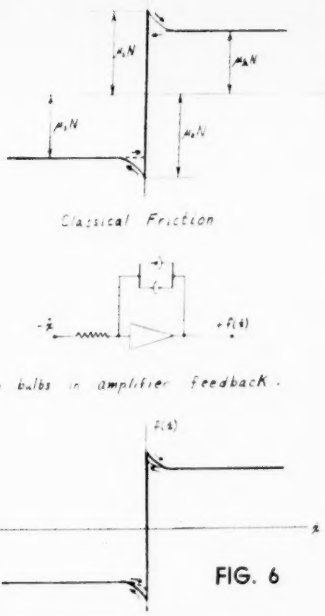
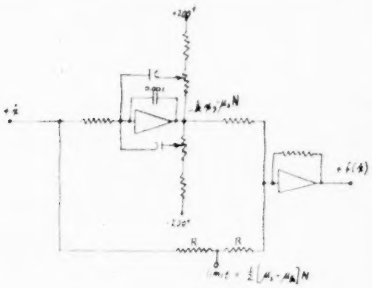


FIG. 6

Figure 6 shows one method attempted, using neon bulbs in the feedback of a high-gain amplifier. This approximates the classical friction characteristics in that the firing voltage of the neon bulbs is higher than the sustaining voltage. However, on the return to 0 voltage the neon bulbs do not follow a straight line to the origin but return to some intermediate voltage between the level indicated by $\mu_k N$ and $\mu_s N$.

Another disadvantage of the neon bulb approach is that no control can be exercised over the value of $\mu_s N$ and $\mu_k N$ without considerable additional circuitry.

The second method of approximating classical friction is shown in Figure 7. Here complete control can be



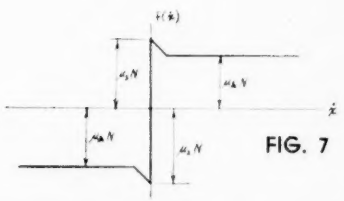


FIG. 7

exercised over the value of $\mu_s N$ and $\mu_k N$ but the hysteresis effect is not realized.

An NACA report gave the tire-to-ground braking friction characteristics shown in Figure 8. It is interesting to note that at zero slip-speed a certain friction occurs, but as the slip speed is increased to 16-20% the friction force peaks and then falls off as higher percent slip-speed is achieved. This characteristic can be reproduced nicely on a diode function generator since no hysteresis exists. The analog computer circuit in Figure 8 shows a means of simulating the tire-to-ground friction force, when no slip occurs as well as when it does. Briefly, the output of the operational amplifier is proportional to the torsional tire deflection angle until slippage occurs. At that time the amplifier is cut off, and the tire-to-ground friction force is exactly equal to the output of the function generator.

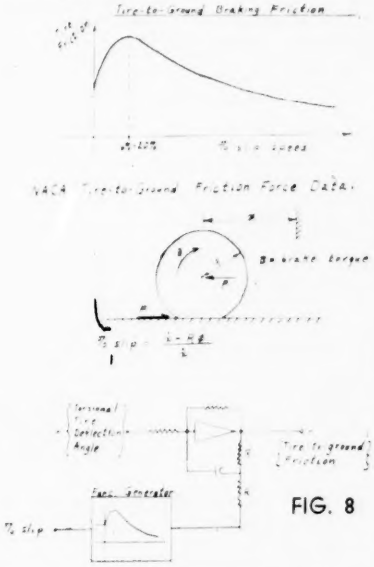


FIG. 8

The second part of P. J.'s talk was based on work on switching circuits performed at Goodyear Aircraft by *Nick Diamantides*. Figure 9 shows the circuit and attendant waveforms as used for an auto-correlation problem, and for a simulation involving time delay. Apparently some problems exist in the selection of the diodes and resistor values. Also, problems arise when the switching voltage is less than the signal voltage. Nick presented this work in detail at a Wright Field Symposium, and an account of it has appeared in a magazine* on antomatic control.

*You could have given us the name, Jerry. We often mention unsavory things in these columns.

Jerry Kennedy remarked that this circuit operates something like a time division multiplier, and P. J. agreed. Asked about the resistor values, P. J. suggested that Diamantides be contacted directly for details.

Larrowe on Frequency Response Measurements

Vern Larrowe (Willow Run Research Center, Ypsilanti, Mich.) gave an interesting and timely talk on "Frequency Response Measurements With an Analog Computer" and the use of general-purpose analog-computer circuits for determining Bode and Nyquist plots. A complete treatise of the subject can be found in the University of Michigan report, "Application of a Gas Turbine Engine Performance Computer to a Twin Spool Engine." Incidentally, this report contains many other interesting tidbits, and is certainly a worthwhile addition to an analog-computer library.

Vern reviewed the normal method for determining frequency response measurements, which effectively involves driving the component under a sinusoidal test voltage, $E_i(\omega t)$, and comparing it to the output of the driven device with respect to amplitude and phase angle. One method of presenting the data is to prepare a polar diagram whose vector length is proportional to the quotient of output and input amplitude, and whose angle is proportional to the phase relationship of the output and input. The reduction of test data is somewhat complicated if parallel channels

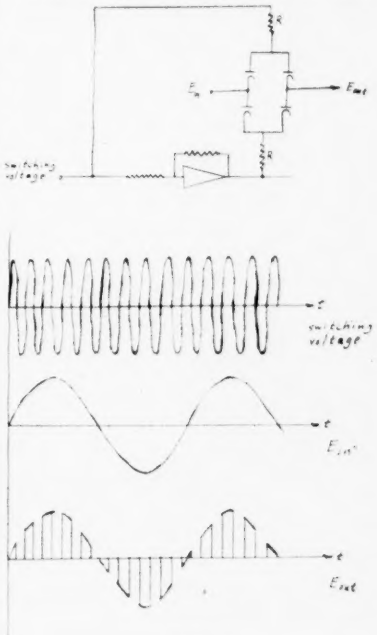


FIG. 9

on a strip-chart recorder are used to record input and output, so an easier method is desirable.

Figure 10 shows the hookup for a semi-automatic data-reduction process. This includes a three-amplifier oscillator for driving the component under test and for generating in phase four quadrature components of the driving voltage. In addition, two amplifiers and an x-y plotter are used. The plotter is used as a milliammeter, and with a bit of manual dexterity, potentiometers 4 and 5 can be adjusted to null the plotter. When this null is achieved, the values of pots 4 and 5 will yield the ratio of the output and input voltages (in-phase and quadrature components). Where the frequencies involved are too high for a plotter, a voltmeter can be used.

Vern also talked about a non-linear system which includes not only velocity but acceleration limiting. Normal transfer-function analysis breaks down for non-linear systems. However, Vern described a technique which makes it possible to determine at what amplitude and frequency the closed-loop system will oscillate for various gains. A comparison between computed and directly-measured data showed close conformity between the two sets.

Tour of NAA Servo Lab

After the talks the Midwestern Council members toured the North American Aviation Servo Lab, which is directed by *William Parker*, and inspected the following Electronic Associates analog computing equipment, which is tied in with physical hardware, i.e., hydraulic, electronic, and pneumatic components of aircraft:

5 control consoles
240 operational amplifiers
28 diode function generators
10 electronic multipliers
12 precision resolvers
38 potentiometer padders
42 servo multipliers
2 reference supplies (±100V at 1 ampere each)
5 strip chart recorders
2 X-Y plotters
12 pre-patch panels

The total power consumption for this facility is 3 kilowatts, and there are three air conditioners with a total capacity of 20 tons. Total floor space at present is 1000 square feet, but the area is being expanded to 2500.

Elizabeth Blackwell is in charge of both the IBM 704 digital computer and the Dynamics Group's RADAC analog facility. *Chuck Walli* directs the analog-computer group, which includes the following EAI equipment:

3 control consoles
148 operational amplifiers
6 diode function generators
5 electronic multipliers
3 precision resolvers
8 potentiometer padders
11 servo multipliers
1 reference supply
4 strip chart recorders
5 X-Y plotters
15 pre-patch panels

This computer lab has over 3000 square feet of floor space.

The tour was particularly interesting to those concerned with the installation of analog computers, for Walli's group is in the process of moving its computer. There are several novel features in the NAA lineup of equipment: the whole facility sits on a false floor and the consoles are located in front of the line of computing cabinets, while the entire laboratory is arranged in an L shape with plently of room for convenience of operation and later expansion.

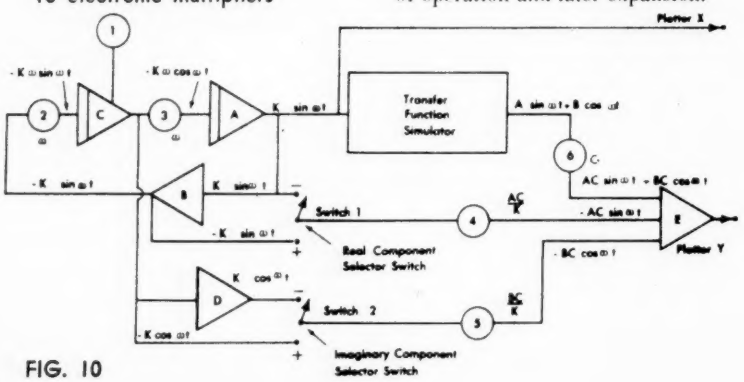


FIG. 10

Information (Without Theory)

The original objective of the Simulation Councils was to get people together under conditions that were conducive to the two-way discussion of mutual problems and half-baked ideas for their solution. At first the meetings were small, and the system worked well, so we grew.

But as audiences grew larger the speakers prepared their papers more carefully and presentations became more formal. Discussion from the floor was inhibited by the size of the audience and the more formal atmosphere, so that the flow of information became almost completely unilateral. As time passed we became more and more like the established professional societies.

To become like the professional societies is precisely what we do *not* want to do: there are too many already! We want to complement them, not compete with them.

In an attempt to reverse the trend, or at least accomplish in some measure our original objective, the Eastern Simulation Council some time ago established comparatively small Study Groups to consider special areas of interest. These have met with some success.

Recently the Midwestern Council surveyed their members as to their interest in a similar plan. Now Jerry Kennedy informs us that those interested in the following subjects should contact the people listed:

1) Aircraft Simulation
M. W. Sayler, General Electric, Evendale, Ohio
2) Analog Computer Equipment and Administration
L. M. Warshawsky, Wright Air Development Center, Dayton, Ohio
3) Analog-Digital, Digital-Analog Conversion
Jerome D. Kennedy, Electronic Associates, Inc., Mt. Prospect, Ill.
4) Control Systems Simulation
John Anderson, Allison Div. of General Motors, Indianapolis, Ind.
5) Ground Vehicles
Ralph J. King, Caterpillar Tractor Co., Peoria, Ill.
6) Instrumentation
William Field, Union Carbide & Carbon Co., Charleston, W. Va.
7) Navigation
Jack Plaster, North American Aviation, Columbus, Ohio
8) Power Plant Simulation
Ralph J. King, Caterpillar Tractor Co., Peoria, Ill.
9) Process Simulation
Warren Jackson, Jr., Standard Oil of Ohio, Cleveland, Ohio
10) Human Physiology and Dynamics
J. B. Clymer, North American Aviation, Columbus, Ohio.

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

How to Evaluate Static Accuracy

Static summing accuracy, being the foundation on which over-all computing precision rests, deserves careful analysis by computer users. A single figure like ".01% accuracy" has little meaning unless supplemented by less ambiguous statements. Fortunately, static error caused by modern high-gain, low-drift amplifiers is negligible; therefore, questions of static accuracy can be answered by discovering how well input and feedback resistors have been matched in order to produce resistance ratios of 1:1, 10:1, etc. The following questions are pertinent.

(1) Exactly *how* are resistors matched? Each with every other? Or each with a few others in a group?

(2) What is the matching error upon installation?

(3) How will environmental conditions such as temperature affect accuracy?

(4) Will accuracy deteriorate with age and use? If so, how much?

(5) Will resistors added to expand capacity at a later date match those initially installed?

Let us examine these questions in greater detail.

Two Methods of Matching Resistors

One method is to match resistors in groups of four or five—each to be used only in conjunction with one or more of the others, as input and feedback resistances for a certain amplifier. This method can provide sufficient accuracy, but computer capacity is unnecessarily limited because input resistors cannot be freely transferred from one amplifier to another as needed.

An alternative is to match each resistor with every other in the computer, so that every element will be available for use wherever needed. The EASE computer people have accomplished this by calibrating all computing resistors against a single master standard carefully maintained under laboratory conditions.

The master standard is a group of 100K resistors specially-selected to deviate from a central value less than ±2 PPM and guaranteed to differ no more than ±15 PPM from an absolute 100K value. 1M computing resistors are calibrated against the ten 100K resistors connected in series. 100K resistors are calibrated against the *average* of the ten 100K standards so that the 10:1 ratio is free from the possible 2 PPM deviation of the standards. 200K and 500K computing resistors are similarly calibrated against group averages to achieve exact 5:1 and 2:1 ratios respectively. Using these calibration practices, all computing resistors in an EASE 1100 Series computer are initially adjusted to *within 10 PPM* of the ideal value.

Effect of Temperature On Static Accuracy

No static accuracy figure is meaningful unless accompanied by a statement of the environmental temperature range over which specified accuracy can be achieved. Because EASE computing resistors are installed in an oven maintained within ±0.5° C of a constant temperature, resistance changes due to temperature are less than 15 PPM—this despite external temperature variation from 65° F to 110° F and line voltage changes from 105 to 130 volts.

Field tests have confirmed the effectiveness of this mode of calibration and temperature control. Figure 1 shows the distribution of 100K and 1M resistors in an operating computer. A fact worthy of emphasis is that measurements were made *at the patchboard* under actual operating conditions; consequently, all possible sources of error have been taken into account. With precision computing equipment, only tests made under operating conditions are dependable because so many unpredictable factors such as slight connector contact resistance, wiring resistance and possible human errors in calibration can influence the theoretical result. Note that *typical resistance deviation is about ± 20 PPM* and maximum deviation is 50 PPM except for 1 delinquent out of 1000 which has strayed to 60 PPM.

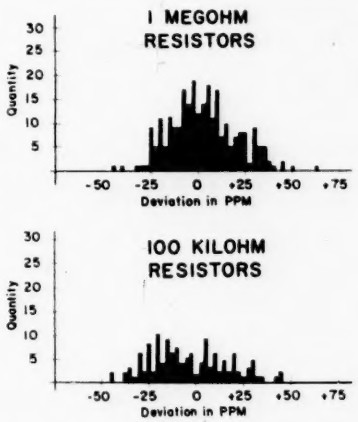


Figure 1. Distribution of all 100K and 1M resistors in 1100 Series computer used at EASE Los Angeles Computing Facility. All measurements made at the patchboard under actual operating conditions.

Aging Effects

The principal effect of age on resistors is to modify resistance values as heat stresses set up in manufacturing processes slowly decay. To forestall this effect EASE computing resistors are heat-cycled four times far above and far below operating temperature in order to remove heat stresses before calibration.

Although no EASE 1100 Series computing resistors have been in service long enough to make a definitive report an stability over a period of years, preliminary tests indicate very low drift. A group of computing resistors, kept at the EASE laboratory for long-term testing, show no greater individual deviation outside the original calibration tolerances than ±15 PPM over a period of six months.

Will Later Expansion Affect Accuracy?

An analog computer user must give due weight to the possibility that an initial installation may require expansion at a later date as new problems are encountered and new solution techniques developed. At that time it becomes important to obtain new resistors matching those originally installed. Here also the use of a single master standard for calibration is advantageous. Provided the master standard has not drifted in value, new risistors can be calibrated to match those in the computer as well as the initial set.

Absolute drift of a few parts per million is difficult to detect with certainty, but all evidence indicates that the EASE standard has not drifted. None of ten basic resistance standards show detectable long-term drift over one year when compared with each other or when compared to other high-stability standards within the laboratory. Since it is extremely improbable that these standards have all drifted the same amount and in the same direction, we infer that the absolute value is holding steady.

C 2

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For more information circle **57** on inquiry card.

Analog Engineers

NAA-Columbus is expanding its Analog Computing Group to handle new problems generated by high performance production aircraft, missile proposals and space studies.

SENIOR ANALOG COMPUTING ENGINEER: Will be responsible for solution of engineering problems arising from design, development and research activities of all engineering groups. Duties include developing analog techniques, circuits, methods, and modes of applications. Industrial experience, research experience, and advanced degree preferred.

ANALOG COMPUTING ENGINEER: Will assist in the formulation, analysis, and solution of problems by use of analog equipment. Problem areas include: aerodynamics, dynamics, heat flow, structures, flutter, fluid flow, implicit synthesis, and system analysis. Degree and related experience required.

Our analog laboratory is equipped with 300 amplifiers and associated non-linear equipment. IBM 704 is used to augment studies performed on the differential analyzer equipment. Write to:

Engineering Personnel, Box IA 579
North American Aviation, Inc.
4300 East Fifth Avenue
Columbus 16, Ohio

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SIMULATION COUNCIL—Cont.

The Steering Committee of the Western Simulation Council, recognizing the need, has also given the matter serious consideration. It has been tentatively decided that the meetings, formerly held only in the afternoon, be made all-day affairs with semi-formal presentations in the morning and discussion groups and facility tours in the afternoon. The best method of encouraging participation in the discussion groups will probably be worked out empirically.

What the answer is we don't know, but certainly one must be found if we are not to become just another Professional Society.

Any ideas?

He Went Thataway:

Norm Irvine to Douglas El Segundo.

Jerry Kennedy up! To Manager of Engineering Sales with his same company, Electronic Associates Inc.

Thot (of the moment)

Editing this *Newsletter* as I fly all the way across the U. S. to the ISA meeting I am reminded, in view of recent accounts of air crashes, of this statement of a Southern gentleman who said that he liked to keep his felt on terra firma—"an' the mo' firma de less terror!"

Computer Events

National Simulation Conference

Dates: 23-25 October 1958
Place: Statler-Hilton Hotel, Dallas, Texas
The conference will be sponsored by the IRE PGEC and the Dallas Section of the IRE.

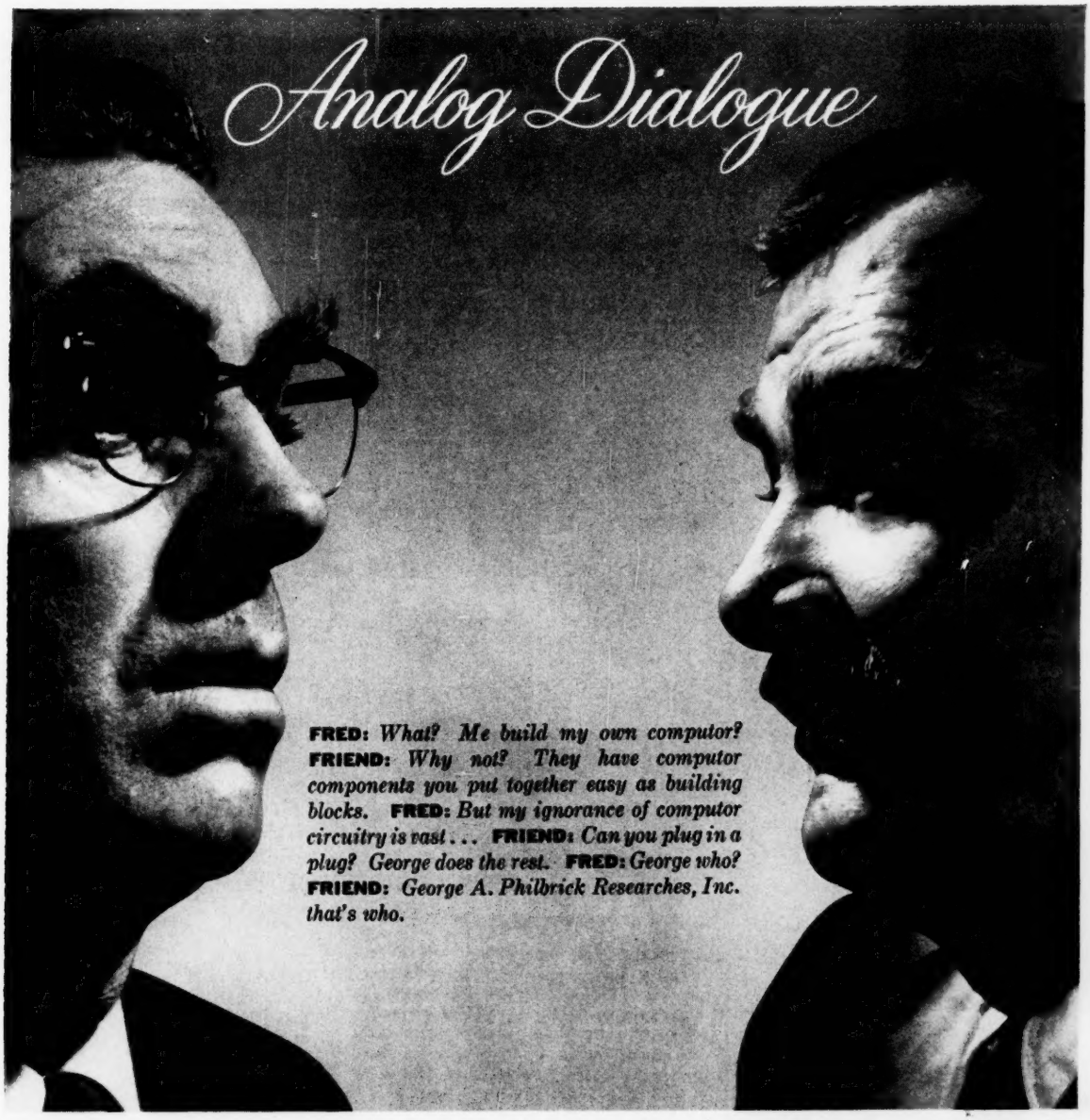
Computer Applications Symposium

Dates: 29-30 October 1958
Place: Armour Research Foundation Chicago, Illinois

Western Simulation Council

Date: 13 November 1958, 1:00 PM
Place: University of California at Los Angeles
Subject: "Applications of Analog Computers to Solutions of Field Equations"

Analog Dialogue



FRED: *What? Me build my own computor?* **FRIEND:** *Why not? They have computor components you put together easy as building blocks.* **FRED:** *But my ignorance of computor circuitry is vast . . .* **FRIEND:** *Can you plug in a plug? George does the rest.* **FRED:** *George who?* **FRIEND:** *George A. Philbrick Researches, Inc. that's who.*

MORAL: *For anything in analog, see Philbrick. GAP/R has the world's most complete line of electronic computors and components. Write for freely given opinions on individual applications.*

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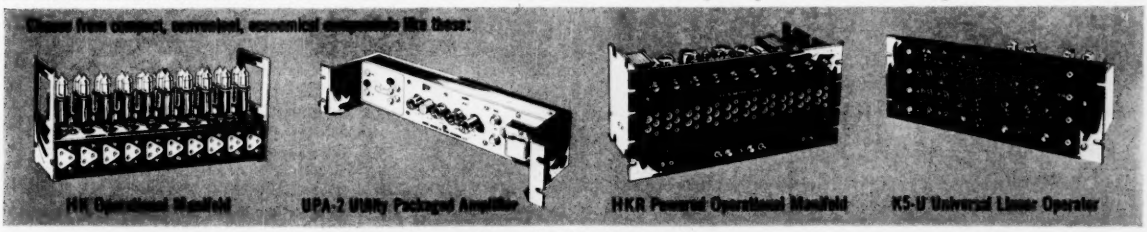
. . . . . The analog way is the model way . . . . .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K5-U Universal Linear Operator

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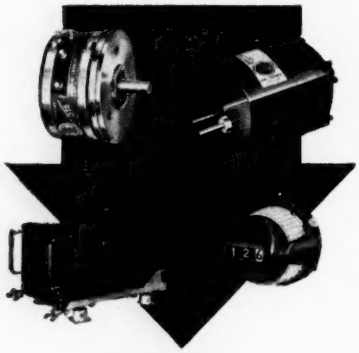

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new instruments

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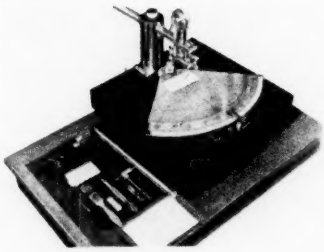
SCALE DRAWING MACHINE

New hand-operated Model Scama allows redrawing of any flat electrical indicating instrument's scale whose angular deflection is no greater than 90°; no calibration curves required. In thermocouple instruments, scale can be redrawn to match inexpensive uncalibrated thermal elements. Special scales are readily drawn for special-purpose instruments.—*Sensitive Research Instrument Corp.*, 310 *Main St., New Rochelle, N. Y.*



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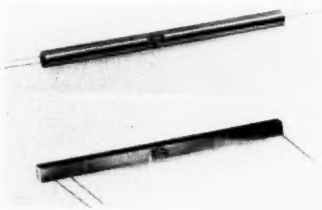
DELAY LINES

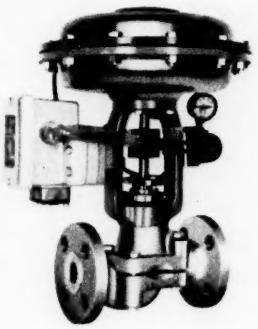


New delay lines for printed-circuit assembly or for conventional mounting offer high ratio of delay to pulse rise time, in minimum space. Other characteristics are precise pulse fidelity; operating temperature range of −55°C to +125°C; excellent temperature stability; linear phase shift; attenuation of 1 db per usec.—*JFD Electronics Corp.*, 1462, 62*nd St., Brooklyn* 19, *N. Y.*

For more information circle **215** on inquiry card.

SPRINGLESS CONTROL VALVE

New Type 1000 control valve features springless operator with preformed Buna-N-Nylon diaphragm. Is equipped with Foxboro or Moore valve positioners. Single-seated split body is available in 1" to 6" size in steel, stainless steel, monel and Hastelloy "C". Ideal for high pressure drops, flashing service, chemicals and slurries.—*Uniflow Valve Corp.*, 19 *Quine St., Cranford, N. J.*



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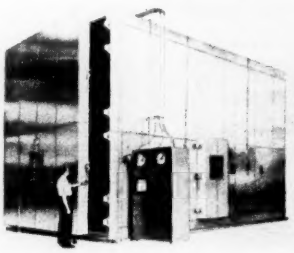
ENVIRONMENTAL TEST CHAMBER

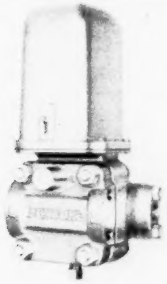


New chamber, ready for push-button operation, has internal working area of 15′ x 12′ x 25′ permitting a large truck to deliver the test item into the chamber. Provides temperature simulation between −100°F and +200°F., with relative humidity simulation between 20% and 95% from +35° to 185°F.—*American Research Corp., Farmington, Conn.*

For more information circle **217** on inquiry card.

ABSOLUTE-PRESSURE TRANSMITTER

New force-balance Type 13AA d/p Cell Transmitter produces a 3-15 psig linear signal proportional to absolute pressure. Mechanism consists of capsule-type, twin-diaphragm sensing element, force bar, flapper-nozzle, feed-

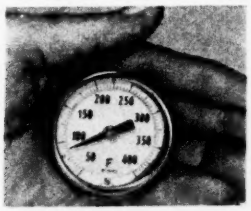


back bellows and relay. Measurement ranges are continuously adjustable between 0-50" and 0-250", or 0-200" and 0-850" of water abs. Transmitter parts exposed to process fluids are type 316 s s. Has overrange protection to 1500 psig. Accuracy is 0.5% of full scale.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **218** on inquiry card.

BI-METAL THERMOMETER

New 2" bi-metal thermometer provides mounting convenience without sacrificing visibility. Graduations are set on a raised ring close to cover glass at same level as adjustable



pointer. Standard ranges are from —80/120°F. to 200/1000°F. and from —50/50°C. Accuracy is within 1% of range. Has 18-8 stainless steel case, ring and stem.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

For more information circle **219** on inquiry card.

FLOW CONTROLLER

New unit controls flow rate of liquids within 0.25% accuracy regardless of variations in pump pressures or liquid viscosities. A special control nut assembly synchronizes a constant-speed motor, valve, Xacto meter and variator, making this positive control possible. Capacities range from 0.5 to 250 GPM. Variator dial permits control settings within a fraction of a percent of range. 4-page bulletin contains details.—*Bowser, Inc., Meter Div., 1300 East Creighton Ave., Fort Wayne, Ind.*

For more information circle **220** on inquiry card.

Conditioned against adverse Environment

BORG TRIMMING MICROPOTS

ASK FOR COMPLETE DATA . . . CATALOG BED-A90

Actual Sizes

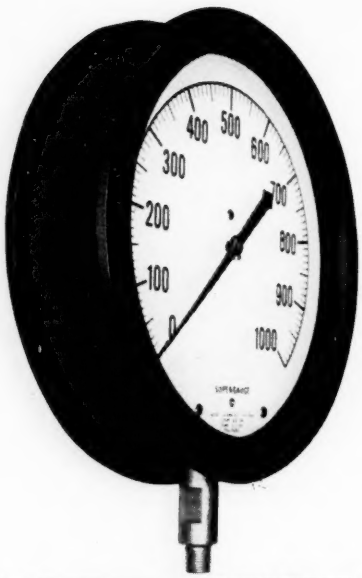
proven performance for subminiature circuits

Midget sized potentiometers for king sized jobs . . . that's Borg 990 Series Trimming Micropots. Sealed construction . . . all metallic parts are corrosion resistant. Three types of terminals . . . printed circuit, solder lugs and insulated wire leads make for easy assembly into any circuit. A screw driver adjusts throughout complete range in forty turns. Contact carrier assembly drive prevents damage when either end of linear excursion is reached. Wide range of resistance values . . . 10 to 30,000 ohms. Other values on special order. Borg Trimming Micropots can be mounted individually or stacked giving you the greatest possible latitude. Let us send you further information on Borg 990 Series Trimming Micropots and the name of your nearest Borg "Tech-Rep" today!

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

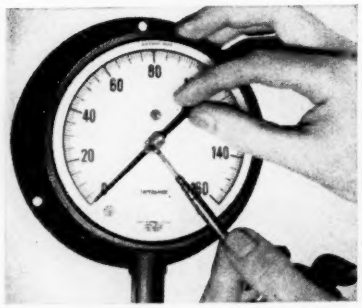
BORG
MICROPOTS
MICRODIALS
MOTORS

For more information circle **61** on inquiry card.

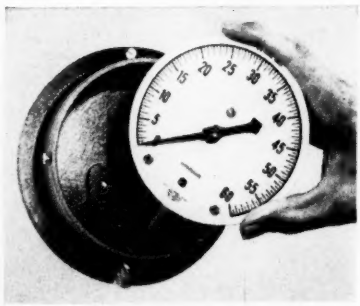


SAVINGS IN MAINTENANCE TIME ALONE PAY FOR EVERY SUPERGAUGE IN YOUR PLANT

For example, with USG's exclusive Arc-Loc movement and Mono-Unit construction, complete recalibrations can be made up to 15 minutes faster than with any other process gauge. Here's why:



NOTE that with Supergauges, adjustments for "zero shift" can be readily made from the front, with gauge in operating position and without removing pointer from the shaft. Location of positive, self-locking worm adjustment screw on *side* of pointer prevents axial distortion of pointer or bending of shaft during adjustment.



NOTE that with USG Mono-Unit design, all Supergauge internals are integrated into a single assembly which can be removed in one quick operation. Complete legends on laminated plastic dials give gauge model number and materials used in construction of components for instant identification. More maintenance minutes saved!

NOTE that with USG's patented Arc-Loc movement, corrections for "scale shape" (linearity) errors and "range" adjustments are both made from the rear. No time is wasted in having to remove the pointer and dial. Each adjustment is a simple screwdriver operation; no special tools are required. In addition, USG's unique locking method eliminates creep during locking, further speeding recalibration time.

AND NOTE ESPECIALLY...

Supergauges meet ASA specifications for Grade AA Test Gauges, including accuracy within ½ of 1% of scale range. They are available in a full line, embracing a wide selection of case styles (including aluminum), case sizes, pressure ranges and materials of construction.

A companion line of SOLFRUNT (solid front construction) gauges is also available with the same fine USG features.

For complete information on SUPERGAUGE and SOLFRUNT process gauges, contact your local USG Distributor, or write for Catalog 1819.

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

For more information circle **62** on inquiry card.

ENVIRONMENTAL CHAMBER

New Model WE-27-130+400H Environmental Chamber has 27 cu ft refrigeration capacity which lowers the temperature of a 50-lb mass load of steel and copper from +400°F to −130°F in 45 minutes maintaining a 1000 watt line load. Conversely, the electrical heating capacity is sufficient to raise the temperature of a 50-lb mass load of steel and copper, excluding the live load from −130°F to +400°F in 15 minutes.—28-page brochure describes details and contains technical information section, atmosphere chart and high-altitude chart.—*Webber Corp., Dept. HF 653, P. O. Box 217, Indianapolis 6, Ind.*

For more information circle **221** on inquiry card.

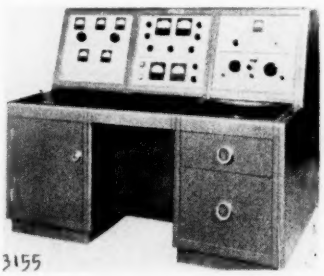
ITV SYSTEM

New ITV system Model 700A consisting of camera, control unit, monitor, and cables features high resolution, high reliability, and ease of maintenance. Camera can be up to 500 ft and monitor 2000 ft away from control unit without line amplifiers. Special multi-conductor cable connects control unit and camera, 75-ohm coax cable control unit and monitor.—Instruction book describes accessories such as lens turret, remote focus assembly, and switcher for camera, video line amplifier, etc.—*Industrial Products Div., International Tel. and Tel. Corp., 15191 Bledsoe St., San Fernando, Calif.*

For more information circle **222** on inquiry card.

AUTOMATIC SHAKER SYSTEM

New Sine-O-Matic Model CP-¾ sine wave vibration testing system is completely packaged; features fully

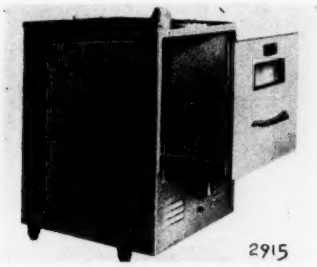


automatic programming and operation; provides peak sine wave vector of 1200 force-pounds when used with Model C10 shaker (will drive C25H or C25B shaker to reduced force). Power output 3000 watts. System supplies its full rated force output over entire frequency range of 5 to 3000 cps without impedance changing or manual power factor correction. All components are mounted in console; only shaker is external.—*Ling Electronics, Inc., 5120 W. Jefferson Blvd., Los Angeles, Calif.*

For more information circle **223** on inquiry card.

ENVIRONMENTAL TEST UNIT

New Model SU-77-6, for special testing of electronic parts, is factory adjusted to 77°F, has a 6-cu-ft file-



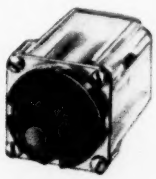
2915

drawer-design chilling chamber; accommodates 50-lb batches; has net thermal capacity of about 300 Btu/hr at 68°F.—*Cincinnati Sub-Zero Products, 3930 Reading Rd., Cincinnati 29, Ohio.*

For more information circle **224** on inquiry card.

POWER RELAY

New miniature version of a power relay in clear polystyrene enclosure with octal plug-in header is available

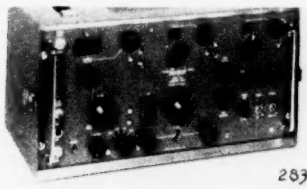


up to 3PDT with standard contacts rated at 10 amps. Can be wired for double make or break operations, a-c or d-c coil.—*Kurman Electric Div., Norbute Corp., 191 Newel St., Brooklyn 22, N. Y.*

For more information circle **225** on inquiry card.

FREQUENCY METER AND GENERATOR

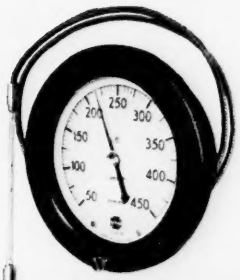
New Model FM-6, said to represent "a completely new concept in frequency measurement," measures and gen-



2836

erates frequencies from 20 to 1000 Mc with better than 1 part in 1 million accuracy. Built-in 1-Mc frequency standard's stability is better than 1 part in 10 million. Its output is available on a front-panel jack. Snap-action crystal oven can be operated from a car battery. Instrument's accuracy extends over wide temperature range (−15°C to 55°C).—*Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles 16, Calif.*

For more information circle **226** on inquiry card.



NEW

FROM U.S. GAUGE

SUPERTHERM dial thermometers

Engineered . . . to equal the premium quality and dependable performance of superior USG Grade AA Supergauge pressure gauges.

Priced . . . at a money-saving value that's news in itself.

Designed . . . in a range of styles and sizes to serve any plant in any industry with the *most comprehensive line of indicating thermometers available from one source today!*

NOW all your requirements for standard, filled system dial thermometers met with one top grade line that features all these specifications. See your USG distributor, or write for Catalog 205.

DIRECT READING—rigid, direct mounting; or "Multi-Angle" type

REMOTE READING—for temperature measurement up to 125 feet from indicator

4 TYPES OF FILLS—organic liquid, gas, vapor, mercury

ALL COMPENSATIONS—complete selection of case or capillary compensation available as required

29 STANDARD RANGES—covering temperatures from −350° to +1000°F

2 CASE MATERIALS—anodized aluminum or phenolic plastic

4 CASE SIZES—3½", 4½", 6" and 8½"

3 CASE STYLES—turret, front flange, or back flange mounting, with choice of bezel

FULL SELECTION OF BULBS—virtually endless combinations of bulb sizes, shapes, materials, and connections.

Find Your Nearest Distributor in The 'Yellow Pages'

UNITED STATES GAUGE USG

Division of American Machine and Metals, Inc. • Sellersville, Pa.

For more information circle **63** on inquiry card.

CUSTOM & STANDARD

Delay Lines

Control Electronics Co. Inc. is a leading designer and mass producer of electromagnetic Delay Lines. A representative group is shown here with the available ranges of delays, bandwidths and impedances. Further information is readily available from our Engineering Dept.

BUILT TO MIL SPECS. FAST PROTOTYPE SERVICE . . . DELIVERY 1 TO 3 WEEKS.

Distributed Constant Delay Lines

CEC DISTRIBUTED CONSTANT DELAY LINE FEATURES

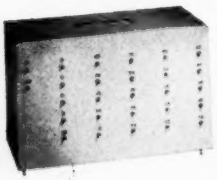
- Lowest cost — reliable performance
- Maximum delay to rise time ratios
- Maximum delay per cubic inch
- Delays to 30 μ secs.
- Impedances: 200 to 10,000 Ω
- Bandwidths to 20 mcs
- Linear phase shift

Variable Delay Lines

Infinite, incremental or decade variable delay lines available in any range of delays and impedances.

Lumped Constant Delay Lines

DELAYS TO 20,000 MICROSECONDS.
BANDWIDTHS to 500 MCS.
Zo FROM 50 TO 10,000 OHMS.



Multi-tapped Lumped Constants available in many configurations

System Delay Lines

Complete delay and pulse systems designed to your needs.

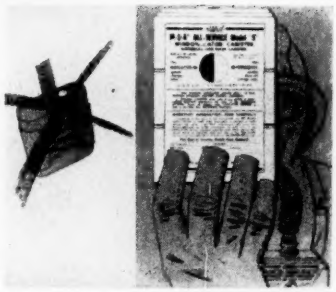
NOTE: Data Sheets on request

CONTROL ELECTRONICS CO., INC.
10 Stepar Place
Huntington Station, New York

For more information circle **64** on inquiry card.

GAS MASK GUARD

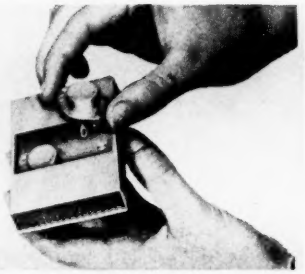
New Window-Cator is a window indicator which shows at a glance condition of gasmask canister. The left half of the window contains dark blue indicating color, the right half a light blue reference color. When the two colors match, the service life of the canister for protection against carbon monoxide is spent.—*Mine Safety Appliance Co., 201 North Braddock Ave., Pittsburgh 8, Pa.*



For more information circle **227** on inquiry card.

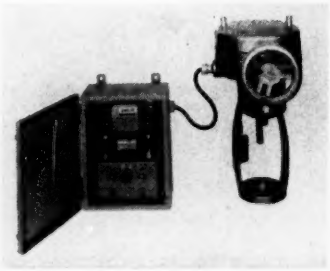
ELECTRONIC-CIRCUIT COOLER

New compact, corrosion-resistant, anodized all-aluminum coolers conduct heat away from transistors diodes or rectifiers through thermal contact with a finned plate. Systems equipped with refrigeration cooling, ram air, or blowers provide suitable air supplies for the coolers. Two module sizes, 2½" and 3¾" are available.—*Modine Mfg. Co., Industrial Div., Racine, Wis.*



For more information circle **228** on inquiry card.

ELECTRIC VALVE POSITIONER

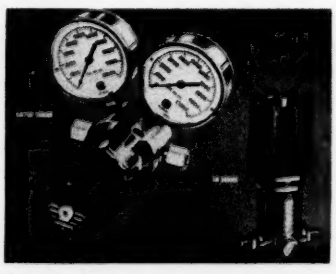


New all-electric transistorized positioner eliminates need for auxiliary hydraulic and pneumatic valve-actuating systems. A 1/40-hp 2-phase induction motor drives the actuating shaft through a gear train and a ball-screw mechanism. The explosion-proof positioner operates from most standard electric controllers. Stroke is field-adjustable from ½" to 2"; stem speed is 0.15 in/sec; maximum thrust is 1000 lb with standard gear train.—*Norwood Controls Div. of American Standard Products, Norwood, Mass.*

For more information circle **229** on inquiry card.

GAS REGULATORS

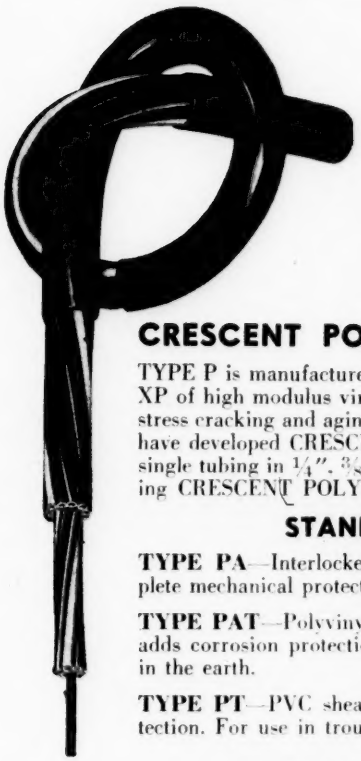
New GD700 series and LR series are regulators designed for testing of pneumatic components and for operating gas systems at inlet pressures of 7000 psig max and operating temperatures from −67° to +200°F. The G-700 series is for high capacity testing, the LR series for dead end and low capacity. Spec sheets give details.—*Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.*



For more information circle **230** on inquiry card.

CRESCENT
POLYETHYLENE
INSTRUMENT TUBING

Costs Less—Is Easier To Install



SIX DIFFERENT TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is 2 to 37 precision Polyethylene tubes *spirally cabled* together for greatest flexibility. The tubing assembly is protected against mechanical injury by an interlocked galvinized steel armor, Polyvinyl Chloride sheath, or other sheaths, as below.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING

TYPE P is manufactured from the best high molecular weight virgin Polyethylene compound and TYPE XP of high modulus virgin Polyethylene compound selected for their superior resistance to environmental stress cracking and aging. Extensive research, improved manufacturing methods and rigid test standards have developed CRESCENT Polyethylene tubing to its present level of highest quality. It is furnished as single tubing in ¼", ⅜" and ½" sizes in up to eight bright colors. It is used exclusively in manufacturing CRESCENT POLYETHYLENE MULTITUBE in types as follows:

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

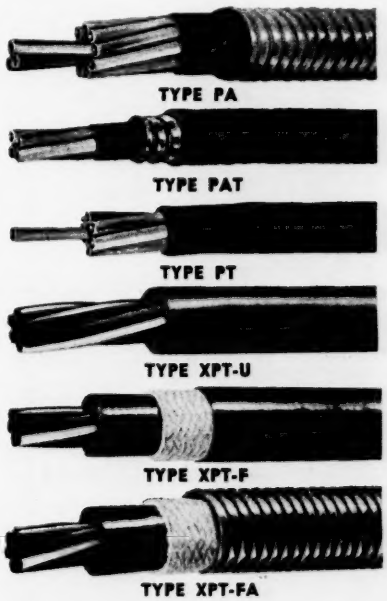
TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

SPECIAL SERVICE TYPES

TYPE XPT-U—Extra heavy PVC sheath over high modulus TYPE XP tubing permits direct burial, or use above ground where subject to moderate abuse.

TYPE XPT-F—Same as XPT-U with heavy asbestos braid and outer PVC sheath. Provides time delay in event of flash fire.

TYPE XPT-FA—Same as XPT-U with heavy asbestos braid and interlocked metallic armor. Provides complete mechanical protection, as well as time delay in event of flash fire.



Write for complete information on these types, as well as types employing copper or aluminum tubing.
Ask for new bulletin No. 458.

CRESCENT INSULATED WIRE & CABLE CO.

TRENTON, N. J.

For more information circle **65** on inquiry card.

Telemeter
ANY VARIABLE
from Remote Points

MODEL 1025 Transmitter

MODEL 1090 Receiver

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

For more information circle **66** on inquiry card.

RADIATION ALARM

New Gammalarm makes it safer to use radioactive isotopes; responds directly to a level as low as 3 mr-hr

(1/100 of recognized safe permitted dose). When detecting radiation that exceeds level preset by user, it flashes red light, rings bells and locks all doors to working areas. When safe radiation conditions prevail, green light indicates safety. Power failure is indicated when both lights go out. —*Picker X-Ray Corp., 25 S. Broadway, White Plains, N. Y.*

For more information circle **231** on inquiry card.

SERVO COUPLINGS

New line of Flexible Servo-Couplings combine zero backlash, low inertia, and high flexibility with $\frac{7}{16}$" length and $\frac{3}{4}$" dia. Bores available $\frac{1}{16}$" through $\frac{3}{8}$". Misalignments permissible are ±5° angular and ±0.015" linear.—8-page bulletin gives details.—*Renbrandt Inc., 6 Parmelee St., Boston 18, Mass.*

For more information circle **232** on inquiry card.

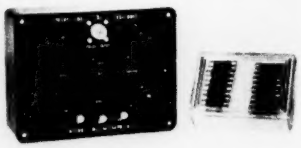
PREDETERMINED COUNTER

New Tally-Count predetermining electronic counter controls batching machine cycling, sorting, materials handling, packaging, and unit flow at speeds higher than 100/sec. Has individual plug-in decades which permit expansion to a 3- or 4-decade counter with no wiring change. Counter can be actuated by relay, photo-electric control, micro-switch, or toggle switch. As totalizing counter, with 4 decades and 4-digit mechanical register, counting capacity is 1,000,000.—*Standard Instrument Corp., 657 Broadway, New York 12, N. Y.*

For more information circle **233** on inquiry card.

DELAY LINE TEST UNIT

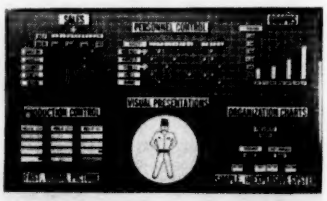
New test jig for inserting adjustable source and load impedance into a circuit when testing delay lines, features plug-in resistors with potentiometer in series for adjusting to exact R; posts for connection to delay lines (for scope probe insertion); plastic assembly (minimizing stray capacity to ground); plug-in capacitor for adjusting input rise time.—*Micro Time Inc., 18228 Parthenia St., Northridge, Calif.*



For more information circle **234** on inquiry card.

VISUAL CONTROL BOARD

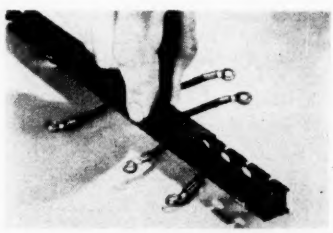
New Magne-trol provides records on magnetic steel board by visual elements of either Alnico permanent magnets, magnetic card holders, accessories. Standard tape, colored plastic bars, circular identification stickers, or magnetic arrows. Standard size is 24" x 36", special sizes can be built. Bulletin contains details.—*Methods Research Corp., 448 Mosel Ave., Staten Island 4, N. Y.*



For more information circle **235** on inquiry card.

MINIATURE WIRING DUCT

New non-flammable vinyl plastic wiring duct features snap-in slot design which allows wire to be laid after terminals have been attached.



Makes a compact raceway for communications equipment, computers, mobile or airborne components, control panel assemblies, etc.—*Panduit Corp., 14461 Waverly Ave., Midlothian, Ill.*

For more information circle **236** on inquiry card.

FREQUENCY STANDARDS

*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L

Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005

Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies: 50 to 400 cycles (Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD *NEW*
TYPE 2007-6
TRANSISTORIZED, Silicon Type
Size 1½" dia. x 3½" H. Wght. 7 ozs.
Frequencies: 400 — 500 or 1000 cycles
Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms

FREQUENCY STANDARD
TYPE 2121A

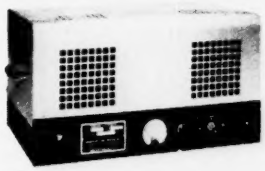
Size
8¾" x 19" panel
Weight, 25 lbs.
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 211IC



Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.
Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.

ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies multi-vibrator type, 40-200 cy.
D—For low frequencies counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

Telephone: PLaza 7-1430

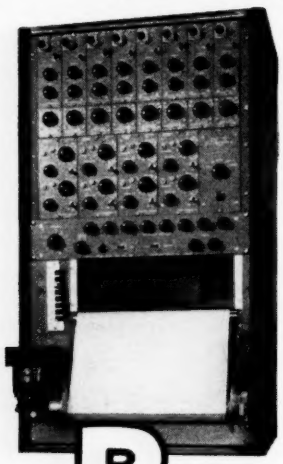
Watch Master
Timing Systems

580 Fifth Ave., New York 36, N. Y.

For more information circle **67** on inquiry card.

OFFNER

All Transistor

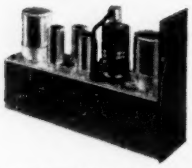


TYPE R

DYNOGRAPH

A direct-writing oscillograph with unmatched features of superiority! Whatever your application for direct-writing recording, the Offner Type R All Transistor Dynograph will do your job *better* and more *easily*. Write on your letterhead for literature and complete specifications.

TYPE 190 *Differential* DATA AMPLIFIER



Zero-drift d-c amplifier with 1/100% accuracy. Linearity of better than 0.05%. Gain stability of 0.01%. Ripple of less than 0.1%. Infinite rejection of common d-c signals. Rapid response to step input. Ambient range −67°F to 170°F. Ask for Bulletin 572.

Type 542 Two-Channel DYNOGRAPH

Rapid response, high sensitivity, stability, compact construction, economical price—all features that make this all transistor, 2 channel unit ideal as a test instrument . . . practical for use at every laboratory bench. Ask for Bulletin 181.

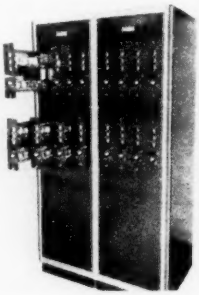
OFFNER ELECTRONICS

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

For more information circle **68** on inquiry card.

CONTINUOUS GAS ANALYZER

New Series 11-3000 Analyzer features no zero adjustments, and a completely "fail-safe" electrical circuit. Unit incorporates diffusion-type heads, eliminating need for sampling



pumps, rotameters, needle valves, flow failure devices, etc. Thus analyzer is well adapted for continuous gas-leakage monitoring in unattended pump and gas compressor stations, tank farms, solvent storage areas, etc. 16-head modular system has slide-out type control chassis.—*Davis Instruments, 45 Halleck St., Newark, N. J.*

For more information circle **237** on inquiry card.

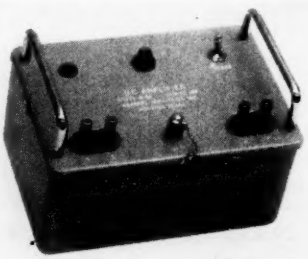
MINIATURE-CONNECTORS

New miniature M-S-type plug, designated "KM", developed for aircraft or missiles, features crimp-type, snap-in contacts to eliminate soldering and to facilitate field servicing. Hermetically sealed receptacles are also available.—Catalog KM-1 contains details.—*Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.*

For more information circle **238** on inquiry card.

D-C AMPLIFIER

New Model M-10 d-c amplifier for galvanometer type recorders provides linearity of better than ½%. 10 mv

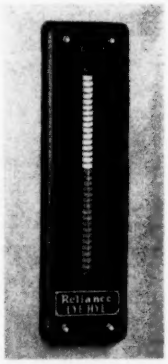


across the ½ megohm input resistance produce 1 ma current in a 1500 ohm load.—*Mandrel Industrial Instruments, 5134 Glenmont Dr., Houston 36, Tex.*

For more information circle **239** on inquiry card.

BOILER WATER COLUMNS

New Eye-Hye column has protruding window which provides 180° reading of boiler water levels through



brightly-illuminated green indicating fluid. Working pressures up to 2500 psi. Can be equipped with visual or aural warning signals.—Bulletin 516B gives details.—*Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio*

For more information circle **240** on inquiry card.

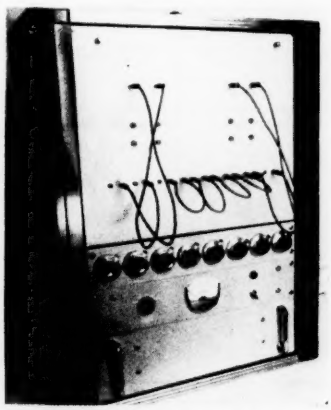
H-V POWER SUPPLY

New high-voltage power supply SC-64, for use in spectrometry, has high degree of stability. Range of 500 to 2000 v and two front-panel controls permit selection of any voltage between 500 and 2000 volts.—*Tracerlab, Inc., 1601 Trapelo Rd., Waltham 54, Mass.*

For more information circle **241** on inquiry card.

CORE PLAN TESTER

New fully transistorized test unit can be programmed for various combinations of full- of half-current out-

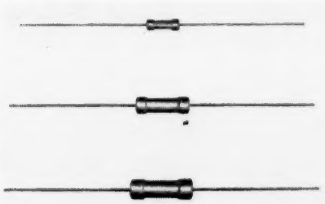


puts. Currents are adjustable from zero to 1.5 amp. Rise time adjustments can be made from 0.3 to 1 usec.—*Transistor Applications, Inc., 50 Broad St., Boston, Mass.*

For more information circle **242** on inquiry card.

HIGH-TEMP RESISTORS

New Electra Series 125 resistors available in three sizes from ⅛ to ½ watt in values from 10 ohms through 5 megohms, feature less than 1%

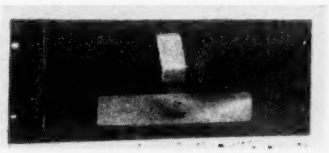


change after 1000 hours of full load at 125°C or 250 hours at 95% humidity with full wattage using the standard mil cycle. Meet or exceed all test requirements of Mil-R-10509B. *Electra Mfg. Co., 4051 Broadway, Kansas City, Mo.*

For more information circle **243** on inquiry card.

TAPE READER

New Dykor Model C301 is a photoelectric perforated-tape reader for any standard punched-tape widths. Reading speed range is 100 to 750 characters/sec. Model has remote con-



trols. Start-stop thyratrons may be triggered by pulses, contact closures, or by shifting d-c levels. Drive motor is controlled by remote momentary switches; on two-speed models, speed is also remotely controlled.—*Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.*

For more information circle **244** on inquiry card.

SERVO MOTOR GEARHEAD

New precision gearhead for size-10 servo motors is also available with size-11 mounting dimensions. Overall

length is less than 1"; weight is 47 grams. Ratios from 6:1 to 274:1 are available. Operating temperature range: −55° to +125°C.—*Clifton Precision Products Co., Inc., 9014 West Chester Pike, Upper Darby, Penna.*

For more information circle **245** on inquiry card.

Apart from a full line of Temperature CONTROLLERS

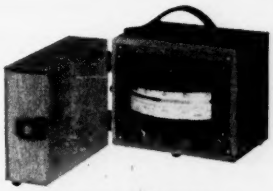
users have proved *these* instruments by WEST

See us at the Metal Show, Oct. 27th-31st, Cleveland, Ohio. Booth #2615

MODEL I SERIES
High Resistance indicating pyrometers

Complete **Control Systems** handily centralizing instruments

MODEL RT SERIES
Resistance Thermometer indicators (and controllers)



MODEL IE SERIES
Portable high resistance indicators

MODEL IN SERIES
Multi-Point indicators with TC switches

MODEL M SERIES
tubeless electronic potentiometer strip chart Recorder

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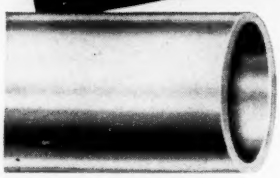
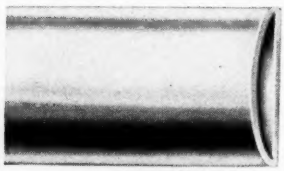
For more information circle **69** on inquiry card.

EVERYTHING IN
Small Tubing
FOR A PRECISION JOB



SIZE

.010" to 1.125" O.D. . . . wall thickness down to 0.0015" . . . held to extremely close tolerances.

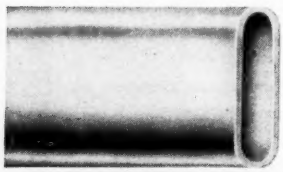


SHAPE

Round, rectangular, oval or square —formed to any specifications.

ALLOY

Copper, brass, aluminum, nickel and nickel-alloys, Ni-Span C, phosphor-bronze and nickel silver.



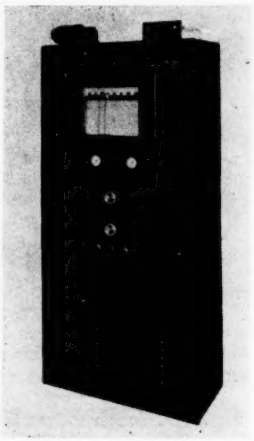
TECHNICAL DATA

. . . to help your product. Write for Tubing Know-How Booklet to Precision Tube Company, North Wales, Pa.

For more information circle **70** on inquiry card.

DEWPOINT CONTROLLER

New dual Dewtronik consists of two complete atmosphere sampling, analyzing, and controlling means, mounted in one cabinet, with one two-record strip chart, indicating and recording controller. The dual instrument is applicable to the simultaneous control of endothermic-type special gas atmospheres as sampled from two generators, one generator and a related or separate furnace, two furnaces, or two zones in the same furnace.—*Ipsen Industries, Inc.*, 715 *South Main St., Rockford, Ill.*



For more information circle **246** on inquiry card.

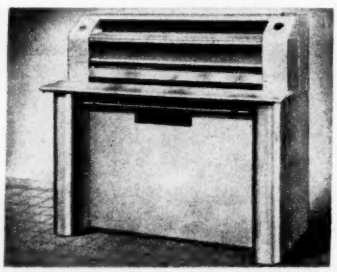
LINE-OPERATED pH METER

New electronic small-size unit is ideal for pH determinations potable, cooling and waste waters, boiler condensates and feed waters, and oil field blends and brines. Permits convenient standardization without buffer solutions.—*Hagan Chemicals & Controls, Inc., Dept.* 410, *Box* 1346, *Pittsburgh* 30, *Pa.*

For more information circle **247** on inquiry card.

WHITEPRINTERS

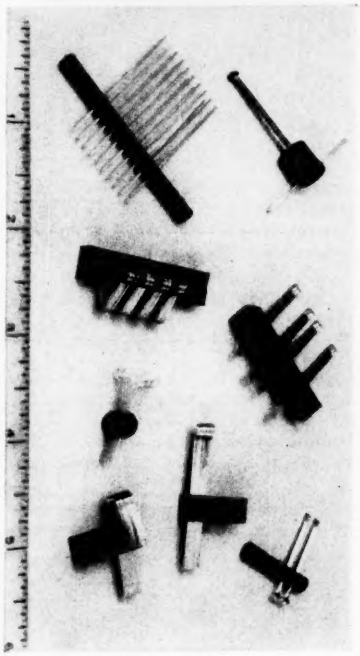
New Scott is a rapid-printing, low-priced, semi-automatic (2 step feed) dry-process whiteprinting machine. It prints and develops at speeds up to 20 ft/min and accommodates prints up to 45" in width and of practically and length. Pamphlet gives details.—*C. F. Pease Co.*, 3967 *N. Rockwell St., Chicago* 18, *Ill.*



For more information circle **248** on inquiry card.

announcing

NEY MOLDED CONTACT ASSEMBLIES



Impressive cost savings and greater reliability are inherent in the use of the new Ney molded contact assemblies. For use with printed commutators, potentiometer windings, slip ring assemblies and printed rotary switches, these assemblies are available in a standard line now being manufactured by Ney, or can be designed to customer specifications.

Seven prime advantages are (1) a complete single or multiple brush assembly ready to use, (2) no welding or soldering, (3) reduction of adjustment during assembly into unit, (4) insured uniformity of desired gram pressure, (5) reduced inspection costs, (6) time tested Ney alloys for reliability, (7) will withstand extremes in operating environments.

SEND FOR LITERATURE

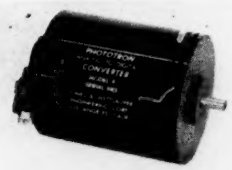
The J. M. Ney Company

P. O. Box 990, Dept. F, Hartford 1, Conn.

For more information circle **71** on inquiry card.

A/D CONVERTER

New Incremental Analog-to-Digital Converter, Model P Series, features 15,000 rpm readout @ 128 cts/rev (Model P-1), 5000 rpm @

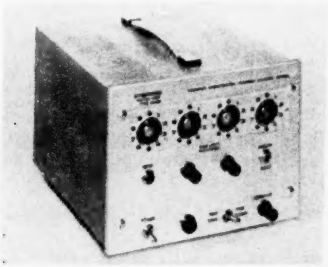


readout 512 cts/rev (Model P-2) 2500 rpm @ readout 1024 cts/rev (Model P-3). Has sampling rate of up to 45,000 cts/sec. Voltage output is 6 volts 1 ma (standard) with up to 18 V available.—*Jones & Wettlaufer Engineering Corp., 11780 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle **249** on inquiry card.

TRANSISTORIZED PRESET COUNTER

New Dynaset features transistors, direct-reading glow-decade counter tubes, and relays of wetted-mercury-contact type with components



mounted on etched circuit plug-in boards. Direct readout is also available through "Nixie" neon tubes, or counter can be adapted to operate printed readout devices. Preset range is 0 to 180,000 counts/min with instantaneous reset (no loss of count); totalizing speed is 0 to 300,000 counts/min.—*Dynapar Corp., 5150 Church St., Skokie, Ill.*

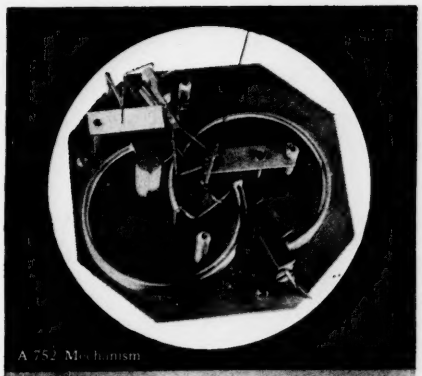
For more information circle **250** on inquiry card.

MOTOR TACHOMETER

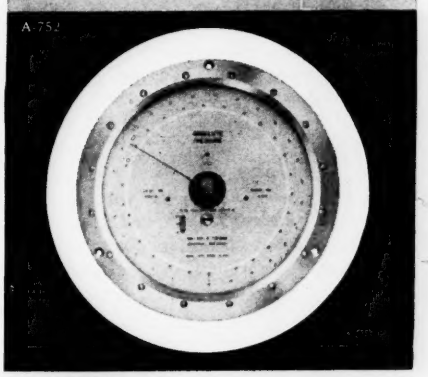
New size 10 damping-type 400-cycle motor tachometer Model SJ9HLX7-1CC features a minimum

stall torque of 0.5 inch-oz and a high output gradient of 0.500 v per thousand rpm. Operating temperature range is −54°C to +105°C.—*Eastern Air Devices, Inc., 347 Central Ave., Dover N. H.*

For more information circle **251** on inquiry card.



NEW W&T BOURDON TUBE GAUGE



liquid column accuracy beyond liquid column range

A combination of Ni-Span-C* Bourdon tubes, a special ratio linkage and custom calibration set these W&T gauges apart. Use of corrosion-resistant Ni-Span-C eliminates temperature compensation, makes the gauge usable in a wide variety of applications. Dual Bourdon tube mechanism provides high accuracy measurements of absolute or differential pressures without applying any system pressure to the gauge case. The special ratio linkage provides low friction, practically no hysteresis. Custom calibration means rapid, accurate readout, as in all W&T precision pressure instruments.

W&T Bourdon tube gauges have:

Max. Range—0-500 p.s.i.; absolute, gauge or differential
Min. Range—0-30 p.s.i.; absolute, gauge or differential
Sensitivity—1:8000
Accuracy—0.2% of full scale range
Hysteresis—negligible
Temperature effect—0.075% of range/10°C

For full information and technical data address Dept. **A-123.48**

WALLACE & TIERNAN INCORPORATED
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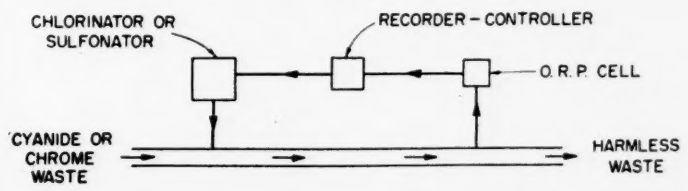

An oxidation-reduction potential cell, monitoring treated waste provides the signal for recording and controlling treatment chemical quantities in a typical W&T waste treatment system.

For Full information on Industrial Waste treatment write Dept. 1-66.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
In Canada, Wallace & Tiernan, Ltd. — Toronto

For more information circle **72** on inquiry card.

New CE-800 ELECTRIC COUNTER

Improved and dust tight enclosed version of the PIC Wizard Electric Counter — unchallenged leader in operating reliability and long count life for more than thirty years.

Accurate Counting at Low Cost

200 million Count Life—sustained accuracy and lowest cost per 100 million counts.

DC Operating Reliability from AC—through built-in rectification.

Tested at 1000 CPM—speeds to 1600 CPM with suitable actuation.

Only 5 watts input—operates from plate of electronic tubes.

Balanced armatures—reduce effect of vibration on air borne equipment.

Dust tight enclosure—die cast aluminum with gasket seal.

Enclosed wiring compartment—for wiring without breaking dust tight seal.

Six-digits; enclosed and panelmount models; knob or key reset; all standard frequencies and DC: standard voltages to 230.

See your PIC Distributor or send for Catalog.

Endurance RATED
Stroke Counters.
Revolution Counters
Electric Counters and Actuators.
Coil Winding Counters.
Automatic Batch Counters.

Production Instruments
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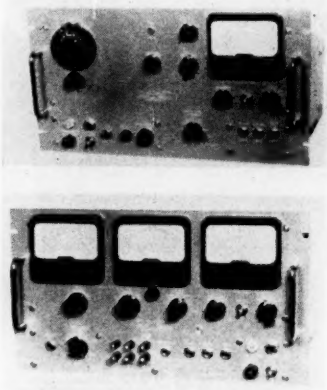
42 Branch Offices and Representatives serving USA and Canada

For more information circle **73** on inquiry card.

NEW INSTRUMENTS

ENVELOPE DELAY METER

New Types 451-A and 452-A Envelope Delay Meters measure absolute amplitude and relative delay characteristics of 600-ohm transmission lines, lumped constant networks, etc., in frequency range of 200 cps to 24 kc. Overall precision and accuracy is



±50 usec. Transmitter 451-A can be used at one terminus of the line and Receiver 452-A at the other. The frequency meter on both transmitter and receiver indicates the carrier frequency; error is less than ±2.5% full scale. Output level is adjustable in 5 db steps from −20 ohm to +10 dbm. Receiver accepts data from ±10 dbm to −35 dbm peak power. Delay meter scales are 2 ms and a 20 ms.—*Acton Laboratories Inc.*, 531 *Main St., Acton, Mass.*

For more information circle **252** on inquiry card.

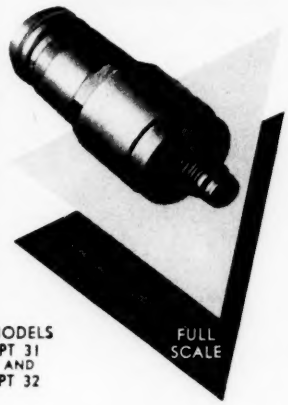
BENCH TYPE TESTER

New Quick-Test hydraulic instrument performs tensile, compression, shear and transverse-deflection tests up to 160,000 psi on 0.252" dia samples. Is adaptable for testing resistance under various compression loads.—Literature available.—*Truck Scale & Research Corp., P. O. Box* 1047, *St. Petersburg, Fla.*

For more information circle **253** on inquiry card.

Dynisco

Miniature
PRESSURE TRANSDUCER



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Unbonded Strain Gauge

HIGHLIGHTS

► EXTREMELY SMALL FLUSH-MOUNTED PRESSURE DIAPHRAGM

► HIGH NATURAL FREQUENCY

► ½ % ACCURACY

► STANDARD UNITS GUARANTEED AND TESTED TO +300°F

► UNITS AVAILABLE TO OPERATE AT +500°F

PRESSURE RANGES

PT 31 0-300 to 0-5,000 PSI
MOUNTS IN 5/16-24 THREADED HOLE
REQUEST BULLETIN NO. 131

PT 32 0-6,000 to 0-15,000 PSI
MOUNTS IN ⅜-24 THREADED HOLE
REQUEST BULLETIN NO. 132

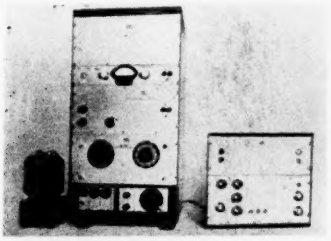
For more information on Dynisco pressure, force, flow, and displacement pickups, write:

DYNAMIC INSTRUMENT CO.
42 Carleton Street
Cambridge 42, Mass.
UN 4-7280

For more information circle **74** on inquiry card.

SCINTILLATION SPECTROMETER

New exclusive design introduces new concept in automatic data processing in the field of atomic instrumentation, providing automatic histogram-plotting of integral or differential spectra. Against the conven-

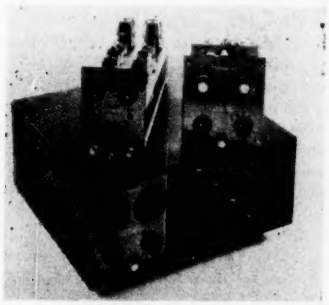


tional way, which uses a single channel spectrometer, attaching a motor drive to the base line, and replacing the scaler with a ratemeter and recorder, thereby developing a counting-rate vs base-line curve, this instrument utilizes a step drive rather than continuous drive on the base line control and a count integrator instead of the ratemeter. This leads to a reduction of "jitter" in the recorder data.—*Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.*

For more information circle **254** on inquiry card.

PRESET COUNTERS

New Preset Electronic Counters Model 320 Series feature two and three decade plug-in modules, plug-in amplifier and control unit, and regulated power supply. Counter is available from two or six decades with additional decades optional. Has

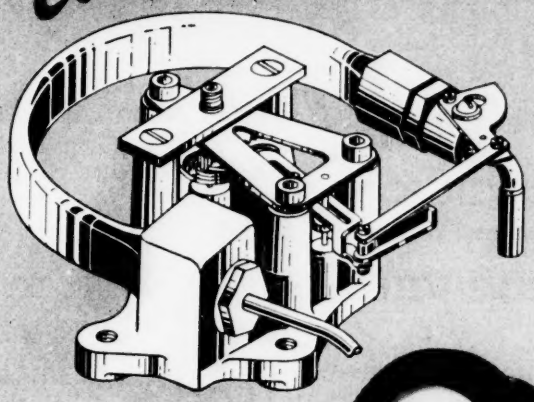


four methods of control when preset count is reached: (1) With switch at "pulse only" a pulse of high negative amplitude appears at both the panel "output" connector and the rear connector, then counter resets itself. (2) In "relay" position a control relay closes up to 5 sec determined by "hold time" control switch. (3) In the "relay latch" position the control relay is held closed indefinitely. A "reset" button on the panel clears the system for the next counting group.—*Erie Instrumentation, Erie Pacific Div., 12932 South Weber Way, Hawthorne, Calif.*

For more information circle **255** on inquiry card.

HEISE GAUGES

NEW Automatic Thermal Compensator



Heat and cold have no effect on the Heise High Precision Pressure Gauge equipped with the new Thermal Compensator. (Patent applied for)

Developed by the Heise Laboratories, manufacturers of the world's finest pressure measuring instruments, this unique device now eliminates all error due to thermal variations. Pointer errors caused by linkage growth and changing modulus in the Bourdon Tube are positively and precisely compensated by the equal and opposite action of a scientifically designed and balanced bimetal bar to maintain calibration through a temperature range from 0° to 100°F.

Even exposed to rapidly changing weather outside the confines of the laboratory, the Heise Gauge upholds its traditional position as

THE STANDARD OF THE WORLD

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $196.75 **DELIVERY WITHIN 30 DAYS**

Write for Catalog

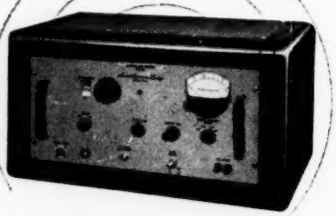
HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **75** on inquiry card.

TEST
INSTRUMENTS
for
LABORATORY/PRODUCTION

Sensitive Detection of Microwave Energy



PRECISION TEST RECEIVER

The AIL Type 130 Precision Test Receiver (30 and 60 Mc standard units available) is a versatile instrument combining a high gain, low-noise figure receiver and a secondary standard of attenuation. It can be used wherever accurate measurements of the differences of r-f and i-f power levels are required. A few typical applications are: noise-figure measurement, measuring characteristics of directional couplers, calibration of r-f attenuators and measurement of selectivity characteristics.

Detailed literature is available on request.

AIRBORNE INSTRUMENTS LABORATORY
A DIVISION OF CUTLER-HAMMER, INC.
1345 NEW YORK AVENUE
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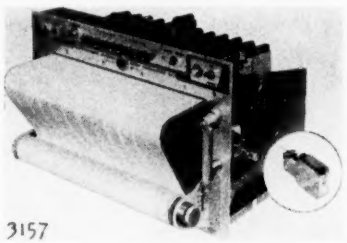
For more information circle **77** on inquiry card.

RECTILINEAR RECORDER

New 12-channel Model RE-12 records with ink or electric writing; features true rectilinear motion, ex-

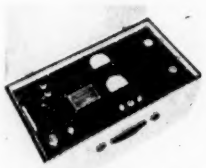


3157

cellent transient response without resonant peaks, overshoot, or ringing; frequency range dc to 200 cps; pushbutton selection of 18 chart speeds from 0.5 cm/hr to 200 mm/sec; event marker; footage indicator; remote operation with plug-in control unit. Recorder element is Model M-133A with 20 ma rms full-scale sensitivity. Dual-channel dc amplifier and various accessories available. —*Massa Laboratories, Inc., Hingham, Mass.*

For more information circle **256** on inquiry card.

INSULATION TESTER



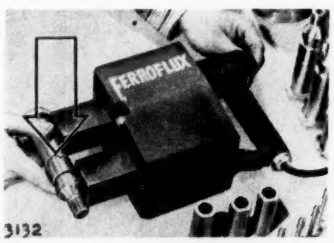
3054

New Model MD-1 portable Insulation Breakdown Test Set operates from a nominal 115-v 60-cps power source or from a nominal 24-vdc power supply; is housed in a plywood case with hinged and gasketed cover as well as rubber feet for added protection when in use.—*Industrial Instruments, Inc., 89, Commerce Rd., Cedar Grove, N. J.*

For more information circle **257** on inquiry card.

MAGNETIC METAL INSPECTOR

New Ferroflux low-cost magnetic inspection device effectively detects both surface and sub-surface defects



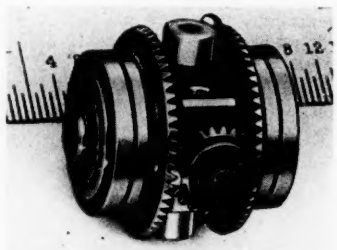
3132

in ferromagnetic materials. Its portability (23 lb) makes it possible to "take the inspection device to the parts instead of taking the parts to the inspection device."—*Ferro Machine & Tool Co., 5514 W. Washington St., Indianapolis 21, Ind.*

For more information circle **258** on inquiry card.

HOLLOW-SHAFT DIFFERENTIAL

New miniature 2-pinion, hollow shaft differential was developed for additive or subtractive operations in precision computing equipment. Iner-



tia is 0.075 oz in^2 with one end gear locked, 0.086 oz in^2 with spider and shaft stationary, 0.298 oz in^2 with input through shaft, one side gear stationary. Total backlash is not greater than 7 min at 2 in oz torque. —*Librascope, Inc., Commercial Div., 40 East Verdugo Ave., Burbank, Calif.*

For more information circle **259** on inquiry card.

ARMORED BUNDLED TUBING

New 24-gauge, galvanized-steel armor of modified square-lock construction, with a cord packing in all joints, offers maximum resistance to vapor and moisture penetration. Available over individual metal or plastic

tubes covered by a thick plastic sheath; with additional plastic sheath extruded over the metal armor; metal or plastic tubes covered with two layers of Mylar-backed tape over which the armor is wound; or as Dekoron Protecto-Pac Type FB which consists of indivdual plastic tubes covered by a heavy plastic sheath, two layers of Mylar-backed asbestos insulating tape, metal armor, and a flame-retardant outer sheath of extruded plastic.—*Samuel Moore & Company, Dekoron Products Div., Mantua, Ohio.*

For more information circle **260** on inquiry card.

CRYSTAL FILTERS

New high-performance crystal filters feature unique design permitting center frequencies of 30 kc to 30 Mc and fractional bandwidths of 0.01% to 6%. Advantages include HF filtering, high selectivity, low passband ripple, low insertion loss, small size and weight, temperature stability, and excellent shock and vibration stability.—*Hughes Products, International Airport Station, Los Angeles 45, Calif.*

For more information circle **261** on inquiry card.

HAND TACHOMETER

New hand-tachometer is specially designed for particularly accurate speed measurements in laboratories,

test beds, and in quality control or production tests. Accuracy is ±0.25% of full scale.—Write for Bulletin 35-78.—*James G. Biddle Co.*, 1316 *Arch St., Phila. 7, Pa.*

For more information circle **262** on inquiry card.

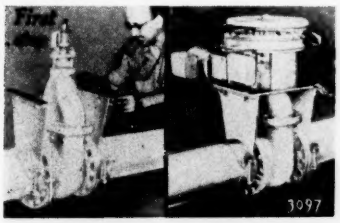
SYNCHRONOUS MOTOR

New Hypersyn permanent-magnet-run hysteresis-start motor features up to 90% efficiency, damping "far superior to any other hysteresis motor," new rotor construction which "combines desirable features of other known motors without their disadvantages . . . . 3 times the output from the same frame size as a conventional hysteresis motor." All speeds and sizes from 1/100 to 1 hp.—*Bekey Electric Co., Inc.*, 1327 *S. Main St., Los Angeles* 15, *Calif.*

For more information circle **263** on inquiry card.

VALVE ACTUATOR

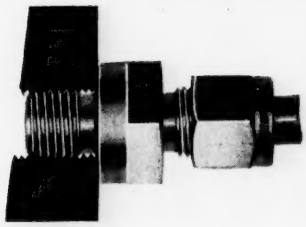
New Valvmatic converts installed valves from hand-operation to electric motor operation; can be installed



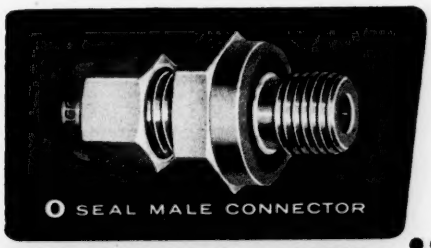
by plant labor with ordinary tools without disturbing piping or replacing existing valves; is push-button-operated. In event of power failure, valve can be restored to manual operation by removing two pins. Position and torque limits are provided in both directions of rotation to prevent valve injury. Valvmatic can be moved from one valve to another.—*C. H. Wheeler Mfg. Co., 19th and Lehigh Ave., Philadelphia* 32, *Pa.*

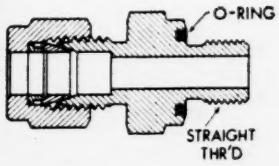
For more information circle **264** on inquiry card.

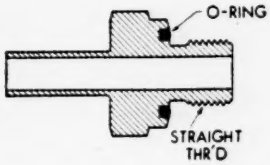
Eliminate even minute leakage



in critical applications with







Swagelok®

O seal fittings

Swagelok O Seal Fittings, with straight machine threads, eliminate every possibility of leakage that usually accompanies the use of ordinary taper pipe threads.

Swagelok O Seal Fittings are completely assembled, ready for immediate use. The O ring seal is held in the body of the fitting and a variety of O ring materials for specific applications is available.

Installation of Swagelok O Seal Fittings is simple. Just drill and tap — no counterboring or port contour cutting necessary. The use of messy pipe dopes or sealants of any kind is completely eliminated.

Screw in Swagelok O Seal Fitting, tighten and the installation is complete. A pressure or vacuum seal can be obtained against any flat surface.

A wide variety of connections is possible thru the use of Swagelok O Seal Adapter.

Swagelok O Seal Fittings are available in all machinable metals and plastics in tube O. D. sizes from 1/16" thru 1".

For name of your local Swagelok Distributor, write Dept. B5

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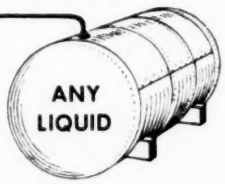
TANK-O-METER

FOR MEASURING TANK CONTENTS
ANY DISTANCE AWAY



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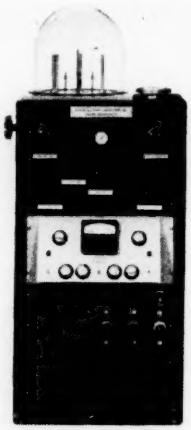
For more information circle **81** on inquiry card.

VACUUM SYSTEM

New BD-40V Production Vacuum System is designed for silicon deposition, vacuum metalizing, etc.



Complete system includes mechanical pump, 3" diffusion pump, cold trap, gaging and controls. Ultimate pressure: 5×10^{-6} mm Hg.—*Bon-De Electronic Laboratories, Inc., Danvers, Mass.*

For more information circle **265** on inquiry card.

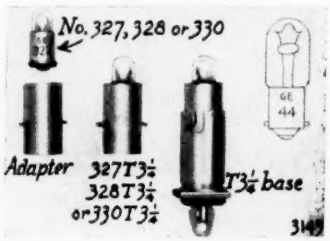
PRINTED CIRCUIT CONNECTOR

New Series UPCC-ML printed circuit connector has straight-through terminals on male member, placing connector body at right angles to printed circuit board—an arrangement that facilitates assembly in many cases. Made with 7, 11, 15, 19, and 23 terminals.—*U. S. Components, Inc., 454 E. 148th St., New York 55, N. Y.*

For more information circle **266** on inquiry card.

SUBMINIATURE LAMPS

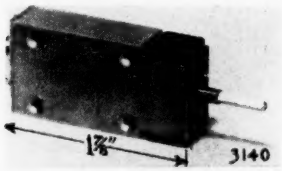
New subminiature lamps can be used instead of No. 44 lamp in standard T3¼ lamp base. Lamp is permanently set in adapter and the two become a single unit. When lamp burns out, adapter is also discarded. New combination lamps can be used in computing and readout devices using standard T3¼ lamp base.—*Industrial Electronic Engineers, 3973 Lankershim Blvd., North Hollywood, Calif.*



For more information circle **267** on inquiry card.

FLAT MOTOR

New Type VS permanent-magnet ball-bearing dc motor, meets MIL specs on humidity, salt spray, shock,



vibration, fungus, etc.; can provide starting torques up to 1 oz-in (depending on rating); is available for intermittent or continuous duty, with armature windings for system voltages from 3 to 50 vdc, and to provide desired speed under specified operating conditions.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

For more information circle **268** on inquiry card.

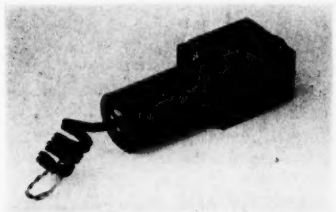
MOTOR-GENERATOR

New Mark 12 Mod O and Mark 12 Mod 1 each combines a Size 15 servomotor with a Size 15 tachometer-generator, both of 1.437" diam. Motor can be furnished for 115 v on both phases, or with 115 v on fixed and 230 v on control phase, all 400 cps. Stall torque 1.45 oz-in; no-load speed 4800 rpm. Tachometer-generator portion is for operation on 115 v 400 cps; has a gradient of 3.2 mv/rpm.—*G-M Labs., Inc.*, 4300 *N. Knox Ave., Chicago* 41, *Ill.*

For more information circle **269** on inquiry card.

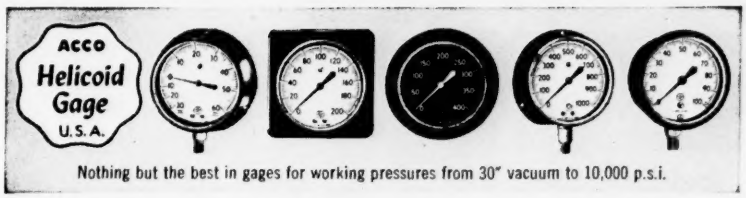
EXPLOSIVE VALVE

New normally-closed compact light-weight SEV-22 Explosive Valve with a self-contained explosive squib is a dead-tight, shut-off valve for storage of gas or liquid under high pressure at temperatures from −65° to 160°F. Maximum operating pres-



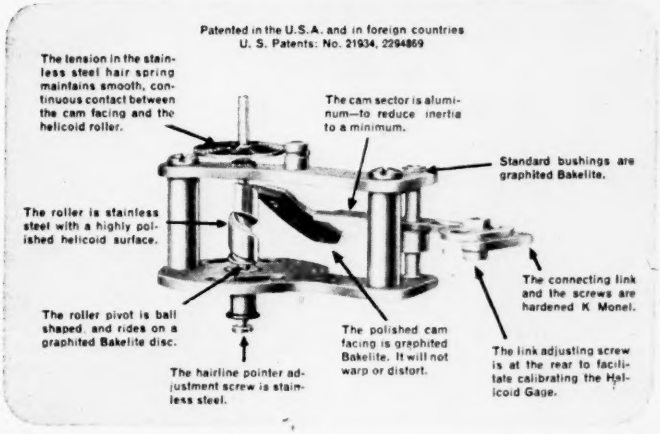
sure: 6000 psig; proof pressure: 10,000 psig. One amp electrical current is required to fire the explosive squib and open an unobstructed flow passage with an equivalent orifice of 5/32" dia in 0.002 sec. Products of combustion are completely sealed in the explosive chamber and the diaphragm is trapped by the ram eliminating any possible contamination of the system by this foreign material.—*Conax Corp., Explosive Products Div., 2300 Walden Ave., Buffalo 25, N. Y.*

For more information circle **270** on inquiry card.



Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
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The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage

The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and/or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

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TRADE MARK

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CONSULT DIGITRONICS CORP., designers and manufacturers of high reliability, minimum volume DYKOR* Lumped-Constant and Continuously Variable Delay Lines . . . custom-crafted, *quality* units at the lowest possible price. Offering delays of from milli-microseconds to multi-milliseconds, precision-engineered DYKOR Delay Lines deliver proven long life and peak performance even under the most adverse conditions. Available in delays, shapes, sizes and terminal arrangements to suit your requirements.

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- HERMETICALLY SEALED, EPOXY-MOLDED OR OPEN CONSTRUCTION
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- WIDE TEMPERATURE RANGE
- LOWEST TEMPERATURE COEFFICIENT
- MEET ALL APPLICABLE MIL SPECIFICATIONS

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- EXTREME ACCURACY
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IT'S DIGITRONICS, TOO, FOR DIGITAL HANDLING AND CONTROL SYSTEM DESIGN AND ENGINEERING!

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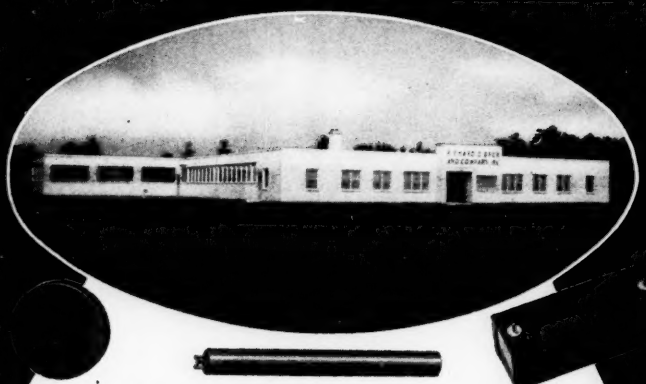
Brew Delay Lines



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DELAY LINES DESIGNED TO YOUR SPECIFICATIONS

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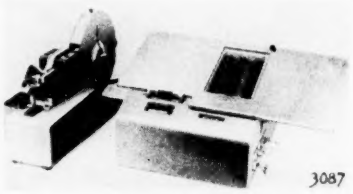
DESK-TOP DATA PROCESSOR

New Data Processor, for use with tabulating equipment and systems, and computers, cuts tabulating card



3087

files by 50% and doubles productivity. It accepts fixed data from tabulating or edge-punched cards and variable data through its simple keyboard. These two data inputs are automatically combined and punched out on tape. Tape output can be fed directly to a computer or to a tape-to-card converter.—*Taller & Cooper, Inc., 75 Front St., Brooklyn 1, N. Y.*

For more information circle **271** on inquiry card.

VOLTAGE REGULATORS

New Stabiline Type EMT4104U (left) automatically regulates fluctuating ac lines to maintain a constant output voltage regardless of line or load changes; is said to be ideally suited for applications regarding control of loads up to 35 amp. ★ New Stabiline Type EMT25136U (right) provides automatic gradual power run-up and constant regulated voltage for high-priced complex vacuum tubes. Input voltage ranges 108-132 and 216-256. Output voltage adjustable from 9 to 24 with sensitivity within a 1-v band at any setting. Max load 25 amp. ★ New Stabiline TM (tubeless magnetic) automatic voltage regulators, for unattended or critical process applications or where conditions cannot tolerate moving parts, have no tubes, transistors or moving parts. Voltage sensing is accomplished by means of a static reference circuit. Avajlable in 1- and 5-kva ratings for 115-v 60 cps ± 5% single-phase duty. Accuracy within 1 volt at a single frequency for line and/or load and power factor.—*The Superior Electric Co., Bristol, Conn.*

For more information circle **272** on inquiry card.

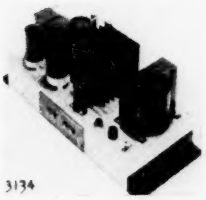
HOUR METER

3145

New explosion-proof hour meter for use on fork lift trucks, gasoline or diesel engines, generators or air compressors which might be located in hazardous locations, is available for 12 and 32 vdc applications. Its case is UL-approved under Class 1, Group D specs.—*John W. Hobbs Corp., Yale Blvd. and Ash St., Springfield, Ill.*

For more information circle **273** on inquiry card.

POWER SUPPLY



New Model GX delivers 30 vdc with 115-125 vac input. Two versions: one delivers 0-2 amp; the other 0-5 amp. Both provide transformer taps so that output voltage can be adjusted to 30 vdc for various values of line and load.—*Gates Electronic Co., 2090 Barnes Ave., Bronx 62, New York.*

For more information circle **274** on inquiry card.

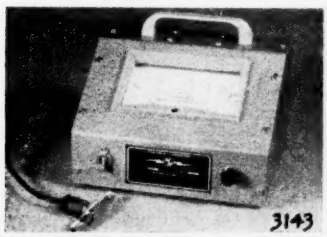
INFINITE RESOLUTION VDR

New Model 85175 Spiralpot is available with either three or ten turns and resistances from 2 to 250 ohms per turn. Unique design: a formed noble-metal alloy. wiper brush continuously contacts a single helically-wound length of noble-metal resistance wire. Infinite resolution and exceptional linearity (0.1% to 0.05%) are advantageous in measurement systems and computers and make possible a simple solution to high-resolution servo systems' "hunting problem."—*G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **275** on inquiry card.

MASS FLOWMETER

New air or gas flowmeter provides direct reading of total mass flow in spite of temperature and pressure



variations; is calibrated directly in milligrams of air per minute; utilizes a heated thermopile element in a flow tube, with thermopile circuit self-compensating for both ambient temperature and rate-of-change of temperature. (Flow tube can be installed in line or placed in a by-pass.) This type of thermal flowmeter has advantages over type utilizing temperature rise across heater: power requirements much less and pressure drop minimal. Two models: MF-1, range 0 to 10,000 mg/min; SM-1, range 0-500 mg/min. Other models available for panel mounting, also with a 5-position selector switch.—*Hastings-Raydist, Inc., Hampton, Va.*

For more information circle **276** on inquiry card.

. . . on the computer reel

FOR HIGHEST-PRECISION COMPUTER APPLICATIONS . . .

has three important features*

Type EP Audiotape is the extra-precision magnetic instrumentation tape that is guaranteed defect-free. Now EP Audiotape is available in a form particularly suited to electronic computers. It is made on both 1.5-mil cellulose acetate and polyester film. Tapes are 2500 x ½". Every reel is tested by a 7-channel certifier before it leaves the factory and is guaranteed to have absolutely no "dropouts" (microscopic imperfections causing test signal to drop below 50% of average peak output).

* **Reel** is Audio's computer reel – an opaque polystyrene 10½" reel with a hub diameter of 5.125". Each reel comes with pressure-sensitive identification labels and a yellow polyethylene drive slot plug.

* **Two photo-sensing markers** are accurately placed on the tape, one 14 feet from the hub end, the other ten feet from the other end. These markers are vaporized aluminum sandwiched between the base and low flow thermosetting adhesive. Both markers are firmly placed and wrinkle-free.

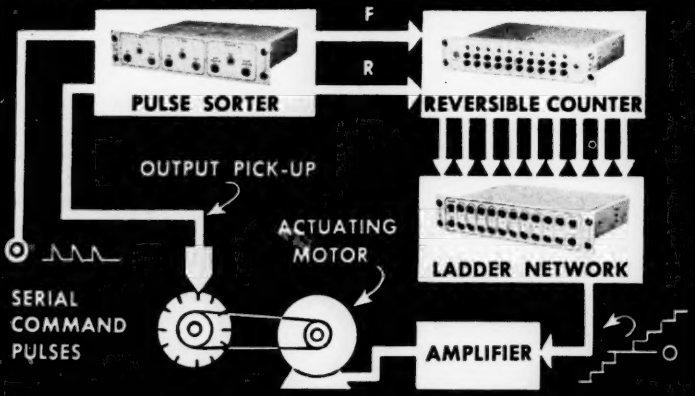
* **Container** is of transparent polystyrene and made especially for the computer reel. A center-lock mechanism and peripheral rubber gasket seal the reel from external dust and sharp changes in temperature and humidity.

EP Audiotape on the computer reel has been used in large computer installations with perfect results. Although the reel, markers and container are designed for specific computers, the tape is the same precision EP Audiotape that has stood the tests of time and operation on hundreds of applications in automation, petroleum seismology, telemetering, and electronic computing. To get the complete specifications for type EP Audiotape on the computer reel – or for a Company representative to call – write on your company letterhead to Dept. TI

AUDIO DEVICES, INC., 444 Madison Avenue, New York 22, N. Y.

For more information circle **85** on inquiry card.

CONTROL SYSTEMS FROM STOCK UNITS!



DIGITAL CONTROL SYSTEM USING REVERSIBLE COUNTER

There's added efficiency in the NAVCOR pioneered concept of completely transistorized system sections—in fact, it reduces the "bit-by-bit" approach to obsolescence. Utilizing NAVCOR system blocks assures integrated, trouble-free operation at the lowest possible cost . . . and your new individually developed control system can be working for you in just a matter of weeks!

Certainly worth looking into—write for NAVCOR manual of over 40 compatible modules.

Navcor

NAVIGATION COMPUTER CORPORATION
1621 Snyder Ave. Phila. 45, Penna.
HOward 5-7700

For more information circle **87** on inquiry card.

Operation and Care of Circular-Scale Instruments

by James Spencer. Includes "trouble" charts for d-c, and for a-c instruments; covers d-c instruments, a-c ammeters and voltmeters, wattmeters, frequency meters, power factor meters and synchroscopes. Clothbound, 90 pages, 1949.

$1.50

Applications of Industrial pH Controls

by A. L. Chaplin. "pH is a concentration variable which responds to and is a measure of the effects of a chemical reaction . . . and follows a non-linear control relationship" presenting unique problems in pH control application. Clothbound, 144 pages, 1950.

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FOR YOUR MgO INSULATED THERMOCOUPLES

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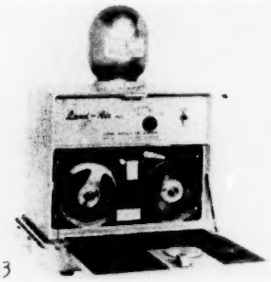
For more information circle **86** on inquiry card.

GAMMA-INTENSITY RECORDER

New battery-operated transistorized GITR (Gamma Intensity Time Recorder) automatically records on

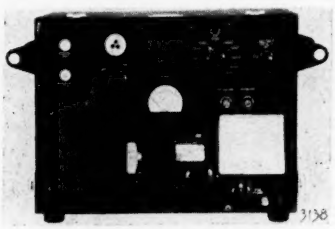


magnetic tape the time and intensity of gamma radiation to which it is exposed. Choice of 12 or 60 hours between tape reloadings. Dose-rate range: 0.1 to 100,000 roentgen per hour.—*Land-Air, Inc.*, 7444 *W. Wilson Ave., Chicago* 31, *Ill.*

For more information circle **227** on inquiry card.

CAPACITANCE BRIDGE

New Type P-582 meets MIL-T-4778 (bears designation TTU 24/E); is a self-contained bridge system com-

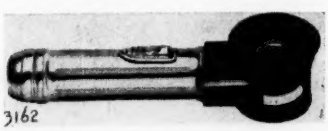


prising a 400-cps oscillator and a sensitive null indicator; is designed to calibrate capacitive fuel-gage testers and is also well suited to general capacitance measurements at 400 cps. Capacitance range 5 uuf to 0.011 uf with an accuracy of 0.1% over most of range.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

For more information circle **278** on inquiry card.

ILLUMINATED MAGNIFIER

New 4½ power achromatic Flash-O-Lens incorporates built-in illumination, sharp-focus magnification,

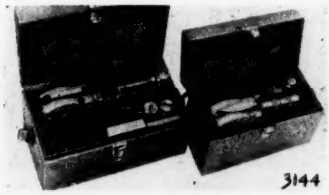


elimination of color and distortion. Battery model illustrated; plug-in type also available.—*E. W. Pike & Co., Inc.*, 577 *Pennsylvania Ave., Elizabeth, N. J.*

For more information circle **279** on inquiry card.

COMPARTMENT CASES

Two new compartment cases are especially designed for Camex Reflex 8; hold this camera and any lens,

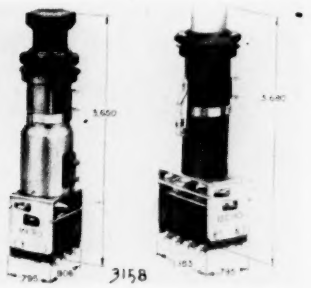


including extreme telephoto.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

For more information circle **280** on inquiry card.

LIGHTED-BUTTON SWITCHES

Two new lighted pushbutton switches: (1) 53PB8-T2 magnetically-held switch employs a small



d-c holding coil which serves only to hold switch in operated position until current is interrupted; (2) 54PB-67-T2 two-position alternate-action switch gives two types of indication —by button position and by use of the built-in indicator lamp. Rating of both is 5 amp 125 or 250 vac; 2, 3 or 4 sp-dt contacts. Translucent plastic buttions are available in a wide selection of colors and shapes. —*Micro Switch Div., Minneapolis-Honeywell Regulator Co., Spring St., Freeport, Ill.*

For more information circle **281** on inquiry card.

ULTRA-HIGH REGULATION POWER SUPPLY

New Model UHR-216 Ultra-High Regulation Power Supply features 0.002% regulation and 100 uv ripple over entire operating range of 160-600 vdc and 0-100 ma; internal impedance less than 0.1 ohm for frequencies as high as 100 kc; transient response 1 usec; typical ten-hour drift 500 ppm. In addition to dc output, independent 6.3-vac outputs, each rated at 5 amp. Instrument is compact (7½"w x 10"h x 15"d) for bench use; available for relay rack mounting. ★Model UHR-236R comprising two UHR-216's rack-mounted on a single panel, has an output voltage range up to 1,200.—*Krohn-Hite Corp.*, 580 *Massachusetts Ave., Cambridge* 39, *Mass.*

For more information circle **282** on inquiry card.

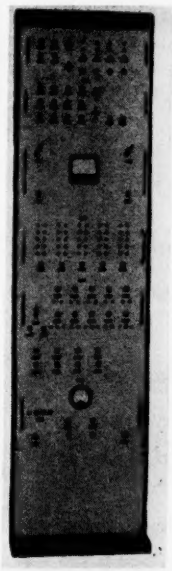
RADIATION PYROMETRIC CONTROLLER

New Pyrotrol is not sensitive to flame, reacts only to radiation emitted by hot object. Optical system focuses

target's infrared radiation upon a photocell, whose output is amplified, triggering an electronic relay. Pyrotrol can "react swiftly to moving heated objects...level from very small objects." Standard operating range 950°F to 2000°F. Models with extended ranges are available. Repeat accuracy is within 1% of scale under normal operating conditions. —*Mason Instrument Co.*, 29 *Elm Ave., Mt. Vernon, N. Y.*

For more information circle **283** on inquiry card.

RESEARCH COMPUTERS



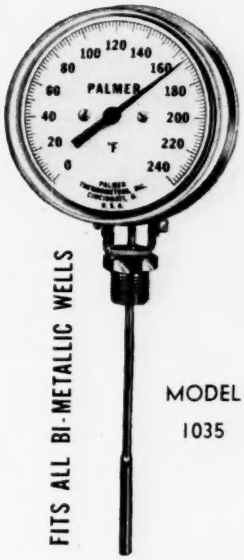
New Minilog, medium-cost analog computer for research problems in colleges and laboratories is manufactured as desk sets in three models, or rack mounted in four models. The basic unit of Minilog contains ten operational amplifiers. Amplification factor of 30,000 gives accurate integration. Drift is limited to 6 mv/day, referred to the input. Amplifiers can be used to add, subtract, integrate, differentiate, multiply, divide, average, limit and provide transfer functions. A Wheatstone bridge is added to give dual operation as resistance checker and as decade input device. Panel-mounted unit includes function generator and multiplier.—*Electronic Brain Enterprises, Inc.*, 1015 *Atkin Ave., Salt Lake City* 6, *Utah.*

For more information circle **284** on inquiry card.

Outstanding Accuracy

PALMER

Dial Thermometer



Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

PALMER

THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, O.

For more information circle **88** on inquiry card.

POST DECITRON ELECTRONIC PRODUCTS

Now . . . low cost . . . accurate "batch" counting for small products.

The *PORTABLE* FCB-1

The Post FCB-1 is a sorting and counting device which incorporates a Syntron vibrator with a Decitron Preset Counter. Model illustrated utilizes a P2 counter, capable of 'batch' counting small objects in any quantity from 1 to 100.

Very small products can be neatly separated on the special conveyor belt . . . individually counted . . . dropped into a 'hold' tray and when the desired count is reached, the entire batch is fed into a waiting box, bag or other container. This latest Post development will feed 300 to 1000 pieces per minute and is **portable!** Size: only 53" long, 18" high, 12" wide. Cost as shown, $3500.

Post will be glad to furnish quotations for models capable of counting larger batches.

Decitron

POST ELECTRONICS

Division of Post Machinery Co. | 165 Elliott St., Beverly, Mass.

For more information circle **89** on inquiry card.

THE ONLY INDEPENDENT COMMERCIAL ENVIRONMENTAL TEST LAB IN THE BOSTON AREA

Acton Laboratories provide defense contractors, industry and government agencies with the most completely equipped environmental testing facilities in the Boston area. Only the most modern, most precise instruments and equipment are used. Acton's Environmental Testing Laboratory is staffed by experienced personnel with the important "know-how." Instrumentation and facilities conform to standard military testing specifications as well as tests for manufacturer specifications.

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For more information circle **90** on inquiry card.

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Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

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ADDRESS REPLY TO P. O. BOX 745 ARCADIA, CALIFORNIA

Balzers means research in high vacuum process

For more information circle **91** on inquiry card.

EVENTS COUNTER

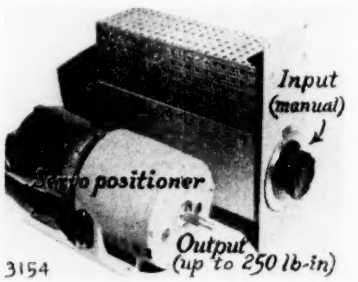
New Electrical Events Counter is available in two versions: Model 122A capable of rates up to 1,000 counts

per second; Model 122B up to 2,000. Both count electrical pulses of at least 12 v (recommended range 12 to 50 v).—*The Hunter Mfg. Co., Iowa City, Iowa.*

For more information circle **285** on inquiry card.

REMOTE CONTROL SYSTEM

New Electrolink 60 closed-loop remote positioner, for industrial applications requiring fast response, high



output torque, and exceptional accuracy, comprises a combined controller-amplifier and a servo drive. Output shaft, driven by high-response magnetic powder clutch, follows movement of manual control (dial, lever, etc.) with accuracies better than 0.25°. System reaches maximum speed in 0.02 sec.—*Lear, Inc., P. O. Box 688, Grand Rapids, Mich.*

For more information circle **286** on inquiry card.

MODULAR TEST EQUIPMENT

New complete line of test equipment is designed so that individual modules can be readily assembled into consoles suited to tests desired by user. Separate modules or complete consoles can be provided for virtually any electrical or electromechanical test program for components and systems. Test modules include:

phase sensitive voltmeters, as VTVM's, synchro resistance bridges, resolver resistance bridges, standard signal servo loops, repeater comparators, transformation ratio modules, synchro index stands, angle position indicators, dual resistance bridges, Wheatstone bridges, resistance decade panels, automatic ohmmeters, automatic resistance checkers, insulation resistance test modules, programming keyboards, tape punches, tape readers, relay-operated voltage dividers, test tables.

Typical consoles include:

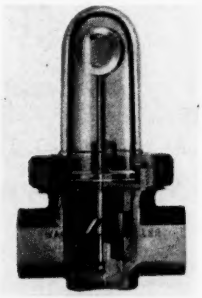
automatic synchro testers, inertial guidance system testers, universal radar test sets, universal resolver and synchro test consoles, ac hi-pot and insulation resistance consoles, resistance limit bridge consoles, wound-component-impedance test consoles, brush-resistance test consoles.

—*Kearfott Co., Inc.*, 1378 *Main Ave., Clifton, N. J.*

For more information circle **287** on inquiry card.

FLOW INDICATOR

New Akron indicater has chromium plated ring spinning under glass dome showing at a glance whether

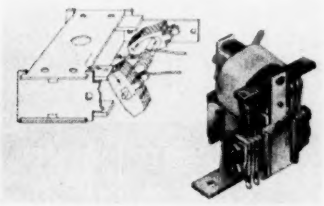


cooling water or oil are circulating.—*McIntosh Equipment Corp., Walker Crosweller Div.*, 15 *Park Row, New York* 38, *N. Y.*

For more information circle **288** on inquiry card.

MAGNETIC TOGGLE RELAY

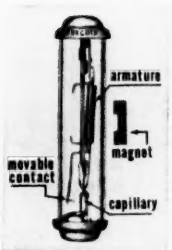
New Magnetic Toggle Relay (MTR), without mechanical latching or electrical holding power, is held in either of its two normal positions by "magnetic detenting". One coil is



used for ac or dc from 1 to 120 v. A positive pulse causes the MTR to toggle to one normal position, while a negative pulse brings it back to its other normal position. Its advantages are: any type of coil; or contact assembly; magnetic memory; no holding power; no drop-out point; fast operation (3 usec).—*American-Monarch Corp.*, 2801 *37th Ave., N.E., Minneapolis* 18, *Minn.*

For more information circle **289** on inquiry card.

MINIATURE MAGNETIC SWITCH



New miniaturized magnet operated capillary contact is hermetically sealed by metallic-end caps for electrical connections. Two types available: n-o Type 6-81 and n-c Type 6-83. Rating: 115 v ac—0.3A, dc—15A; 230 v ac—0.15A, dc—0.7A; 24 v ac—0.9A.—*Mercoid Corp.*, 4201 *Belmont Ave., Chicago* 41, *Ill.*

For more information circle **290** on inquiry card.

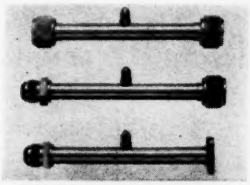
VOLTS TO DIGITS CONVERTER

New completely transistorized Model M-1 Incremental Multiverter converts voltages to digits in a single high-information channel at rates as high as 200,000 conversions per second; can literally follow a single function on an incremental basis. A digital number is always present in output register, change being entered every 5 usec. Counter used accepts three types of input:—1, +1, and 0 (or no change). Variations of basic M-1 can produce square roots or quotients in conversion process. Number of places carried in conversion can be varied to permit interchange of speed and accuracy.—*Packard-Bell Computer Corp.*, 1905 *S. Armacost Ave., Los Angeles* 25, *Calif.*

For more information circle **291** on inquiry card.

PRESSURE-TEMPERATURE MEASURING SECTIONS

New Measuring Sections of stainless steel tube with especially smooth inside finish and close tolerance on eccentricity, in sizes from ¼" to 2" O D

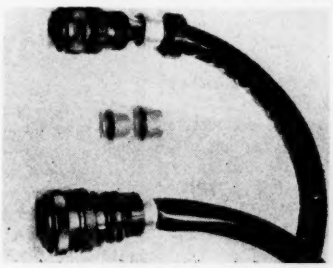


have working pressure ratings to 5000 psig. Conforming to the ASME Power Test Codes and Aviation Industry standards they may be obtained with various ends. Sections with both a pressure take off and thermocouple probe connector also available.—*Kahn & Co., Inc.* 547 *Windsor St., Hartford* 1, *Conn.*

For more information circle **292** on inquiry card.

TERMINATION FERRULES

New ZT Terminators, consisting of two matching aluminum ferrules, allow the attachment of Zippertubing



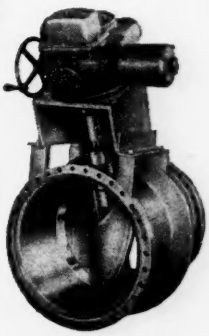
to standard AN plugs and connectors, providing a waterproof closure. They also permit the grounding of Shielded Zippertubing to AN plugs and connectors.—*Zippertubing Co.*, 752 *South San Pedro St., Los Angeles* 14, *Calif.*

For more information circle **293** on inquiry card.

Your plant needs

ROCKWELL VALVES *like these*

"Kwikleen" slide valve for powdered coal, granular materials, flue gases with high solids content, etc.; solids accumulations easily cleaned out by removing bottom plate.



"Stress-seal" butterfly valve for tight shut-off of hot, corrosive or dirty gases to 1300° F. and higher, at 200 p.s.i. Alloy stress band in valve body is inflated by external gas pressure to effect tight seal.

Butterfly valve with simplified bracket and linkage to air operator and valve disc positioner; provides maximum adjustment, minimizes friction, eliminates backlash, chatter and hunting, reduces power requirement in close control applications.

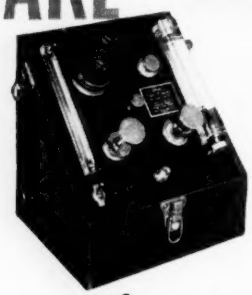
"Slim-Jim" wafer type butterfly valve for low pressure air, gas or liquids; low cost, light, simple, space-saving, easy to install.

What's your valve problem?

W. S. ROCKWELL COMPANY
2128 ELIOT STREET
FAIRFIELD, CONN.

For more information circle **76** on inquiry card.

TAKE GUESSWORK OUT of DEW POINT READING with Alnor DEWPOINTER



Any shop man can quickly...accurately...read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus ...operates on enclosed battery or AC. Available in three ranges for dew points between −20° F. and room temperature, from −80° to 0° F. and −80° F. to room temperature.

Send for Dewpointer bulletin. Tear out this ad and send on your letterhead to: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **92** on inquiry card.

ACCURATELY MEASURES LIQUIDS from *ACETONE* to *ASPHALT*

PETROMETER Remote Reading LIQUID LEVEL INDICATORS are accurate and reliable. Suitable for all stored industrial liquids . . in any tank . . . at any distance. Easy to install . . . and easy to read. Indicators have many unique design features.

write today for Bulletin 6004.

PETROMETER
CORPORATION
43-22 TENTH ST. LONG ISLAND CITY 1, N. Y.

For more information circle **93** on inquiry card.

new plants and mergers

MINIATURE PRECISION BEARINGS, INC. has built a 25,000-sq-ft addition to its plant at a cost of $300,000 which increases the manufacturing facilities by 50%.

MICHROCHEMICAL SPECIALTIES Co. announces expansion of its facilities to 20,000 sq ft with a move to a new location in Berkeley.

SCHAEVITZ ENGINEERING announces completion of its move from Camden to a new 50,000-sq-ft plant in Pennsauken, N. J.

H. H. SCOTT, INC., announces completion of a new 32,000-sq-ft plant in Maynard, Mass.

PIC DESIGN CORP. has built a new 10,000-sq-ft extension to its present building.

ASTROLAB TESTING CORP. is a new company in El Monte, Calif. with advanced-type environmental test facilities which will render services "to prove and improve product performance."

MINNEAPOLIS-HONEYWELL has purchased the MARION ELECTRICAL INSTRUMENT CO., thereby entering the field of measuring and indicating panel meters.

Measure any temperature from −200° F. to +600° F. with one instrument

Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200°F. to +600°F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

TECHNIQUE

TECHNIQUE ASSOCIATES, INC.
POST OFFICE BOX 91
INDIANAPOLIS 6, IND.

For more information circle **94** on inquiry card.

HOKE has completed its new 64,000-sq-ft plant in Cresskill, N. J. and is moving to the new headquarters in October.

EPSCO has set up a new West Coast division at Anaheim, Calif. to be known as Epsco-West.

INDUSTRIAL INSTRUMENTS INC. has purchased Mosher Electronic Controls of Larchmont, N. Y.

BJ ELECTRONICS announces acquisition of **NORTHAM ELECTRONICS, INC.** Facilities will be merged and relocated with the electronics division of BJ Electronics.

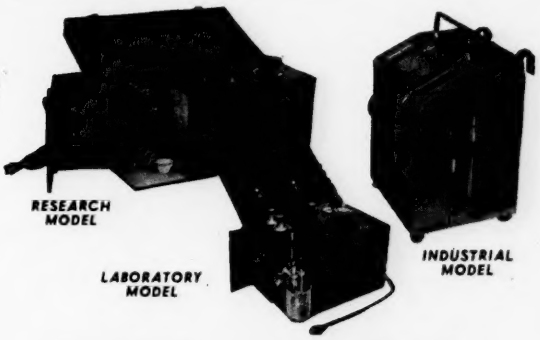
RADIATION COUNTER LABORATORIES has begun construction of a second addition, a new 5400-sq-ft wing.

CURTIS & MARBEL MACHINE CO. has bought the assets of the Instrument Div of **BARBOUR STOCKWELL CO.**

GENESYS CORP. of 10131 National Blvd., Los Angeles, Calif., a wholly owned subsidiary of Chance Vought Aircraft, has entered the field of industrial process control with the manufacture of commercial digital control computer systems. Marketing activities will be under the direction of *John F. Davis*, vice president.

APECO (American Photocopy Equipment Co.) has formed a new subsidiary—the Apeco Leasing Corp.—to handle leasing of its photocopy machines.

LING ELECTRONICS has acquired all of the common stock of the **CALIDYNE CO.**



Cambridge pH Meters

The three portable models illustrated above incorporate new and important advantages. A.C. line operation eliminates battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is direct-reading, continuous-indicating; ruggedly built for plant use.

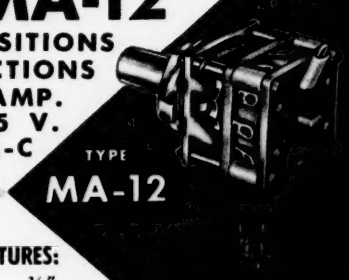
Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Cambridge pH equipment also includes single- and multi-point indicators and recorders. Send for Bulletin 910-M.

CAMBRIDGE INSTRUMENT COMPANY, INC.
3554 GRAND CENTRAL TERMINAL, NEW YORK 17, N. Y.

Pioneer Manufacturers of
PRECISION INSTRUMENTS

For more information circle **96** on inquiry card.

NEW miniature rotary switch
TYPE MA-12
12 POSITIONS
5 SECTIONS
3 AMP.
115 V.
A-C



FEATURES:

- **Small** — ¾" square
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- **Current-carrying capacity** — 3 amp.
- **Interrupting rating** — ½ amp. 115 v. a-c.
- **Voltage breakdown** — 1000 volts RMS
- **Rotation** — unlimited, or limited 2 to 12 pos.
- **Electrical life** — 10,000 cycles at rated load
- Designed to meet MIL-S-3786

ACTUAL SIZE

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R-F ELECTRONICS, inc.
DIVISION OF ELECTRO SWITCH CORPORATION
167 King Ave., Weymouth 88, Massachusetts

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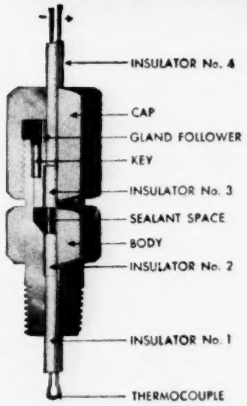
BARE WIRE THERMOCOUPLE GLANDS



U. S. PATENT 2,625,573

provide the only simple positive method for sealing two or more bare wires at pressures from full vacuum to 20,000 psi.

Low mass, unshielded, bare wire thermocouples give almost instantaneous response to temperature changes assuring greater accuracy of measurement and control.

- **Temperature range— −300°F to +1850°F**
- **All stainless steel construction**
- **Complete range of sizes**
- **Available from stock**

WRITE FOR CONAX DATA BOOK SHOWING COMPLETE LINE OF THERMOCOUPLE ASSEMBLIES AND PRESSURE SEALING GLANDS.

conax corporation
2316 Walden Ave., Buffalo 21, N. Y.

For more information circle **97** on inquiry card.

Automatic Control Technology, Modern Theory and their Usefulness

483 + XV pages, 1957, 898 illustrations and 48 tables. Includes 90 advanced papers on control technology, as delivered in original language (English, French, German, Russian; all Russian papers are translated into German; about ½ of book is in English). 9" x 12". Handsome cloth binding. Printed by R. Oldenbourg Verlag, Munich, Germany.

The book is a report of the Heidelberg Meeting, September 25 to 29, 1956, arranged by the VDI/VDE-Fachgruppe Regelungstechnik with the cooperation of the Fachausschuss Regelungsmathematik der Gesellschaft fuer angewandte Mathematik and Mechanik (GAMM); edited by Gerd Mueller for VDI/VDE-Fachgruppe Regelungstechnik.

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CERAMIC
COPPER
*CORNING 707
*CORNING 7052
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GERMANIUM
INDIUM ANTIMONITE
INDOX
MELAMINE FIBER GLASS
MICA, SYNTHETIC
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

*Carried in stock
**Purchased for orders

For more information circle **99** on inquiry card.

people in the news

H. S. Bean

C. F. Robinson

L. G. Cole

Howard S. Bean, formerly with the National Bureau of Standards, has been retained as consultant on flow measurement both by the FOXBORO COMPANY and the DANIEL ORIFICE FITTING CO.

CONSOLIDATED ELECTRODYNAMICS announces appointment of *Dr. Charles F. Robinson* as chief research physicist and *Dr. Leland G. Cole* as chief research chemist.

MINNEAPOLIS-HONEYWELL reports that *Norman A. Fletcher* has been appointed manager of manufacturing for the Valve Division.

SERVO CORP. OF AMERICA announces that *Henry DeRosa* has been appointed sales manager of the Commercial Products Division.

FORD INSTRUMENT CO., div. of Sperry Rand Corp. announces appointment of *W. V. Warner* to the newly created position of general sales manager.

First choice of the rocket and missile industry...
Three superlative Marsh products are widely used and approved by the aircraft and missile industry:
MARSH Pressure Gauges...
because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.
MARSH Needle Throttling Valves...
because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.
MARSH Dial Thermometers...
because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.
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New catalog covers all details
MARSH INSTRUMENT CO. Sales Affiliate of Jas. P. Marsh Corp. Dept. 42, Skokie, Ill.
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

For more information circle **100** on inquiry card.

J. H. Reid

K. R. Waltz

D. C. Duncan

SERVOMECHANISMS, INC., announces appointment of *Mr. James H. Reid* as chief engineer of the Company's Subsystems Division.

NANKERVIS has named *Kenneth R. Waltz* chief engineer.

BECKMAN/HELIPOT DIV. announces appointment of *D. C. Duncan*, general *manager* of the division, to the new corporate position of director of contract sales. *D. C. McNeely*, assistant manager of Helipot, it taking over as acting manager.

VEEDER-ROOT announces that *F. Somers Peterson* of the F. Somers Peterson Co. has retired after 44 years of service as the Company's California sales representative. The Peterson office in San Francisco will be replaced by the newly formed Milligan-Spika Co.

ARNOUX CORP. has added *Dr. Donald J. Gimpel* to its staff as director of research, and *Ellison F. Miller* as chief development engineer.

GIANNINI reports promotion of *D. R. Gero* to the position of vice president and general sales manager.

Sea Water Depth Transducers

FOR SUBMARINE, TORPEDO AND SONAR APPLICATIONS

RANGES:	0-50 TO 0-7500 Feet
DUAL RANGE TRANSDUCERS	
Low Range:	0-50 TO 0-400 Feet
High Range:	0-200 TO 0-2000 Feet

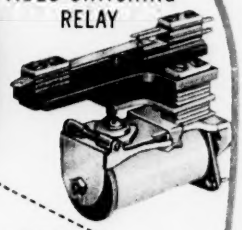
Systems and Instrument Engineers concerned with the problems of underwater depth measurement should write for drawings and specifications.

COLVIN LABORATORIES, Inc.
364 GLENWOOD AVENUE, EAST ORANGE, NEW JERSEY

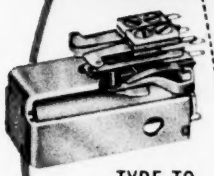
For more information circle **102** on inquiry card.

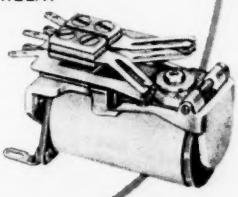
Send for data on these **NEW RELAYS**

TYPE TJV VIDEO SWITCHING RELAY



TYPE TJC VERSATILE COMPACT RELAY





TYPE TQ MINIATURE SENSITIVE RELAY

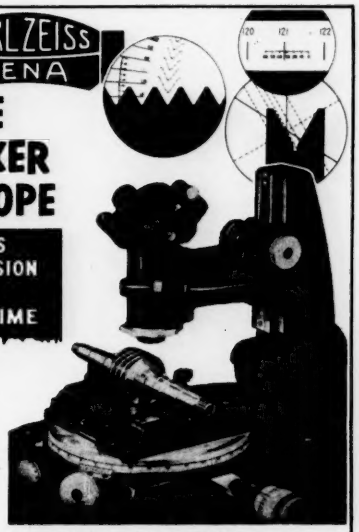
COMAR
ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILL.
RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle **101** on inquiry card.

NEW CARL ZEISS JENA

LARGE TOOLMAKER MICROSCOPE

...PRODUCES HIGHEST PRECISION ....CUTS INSPECTION TIME



At Last... available again the ORIGINAL CARL ZEISS JENA

New Type
LARGE TOOLMAKER MICROSCOPE

. . . **actually measures** (not only compares drawings or shadows) any type of work for shape, angles in degrees and minutes, radii, distances between holes, tapers, spacings, width of keyways and splines, graduations, thread check for angle of flank in minutes, lead and pitch errors of taps, chasers, hobs, cutters and other irregular work **which cannot be checked in any other way.**

RANGE: 6" x 2" — BUILT-IN ROTARY TABLE (11" Diameter) thru 360°

GET THE FULL STORY OF THE VERSATILITY OF THIS OUTSTANDING SHOP AID — Request Circular

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COMPLETE LINE OF PRECISION INSTRUMENTS
200 MG LAFAYETTE STREET • NEW YORK 12, N.Y.

For more information circle **103** on inquiry card.

new literature

AUTOMATION

AUTOMATIC CONTROLS. 52-page Catalog 26 describes automatic controls for heating, ventilating, and air-conditioning systems, including thermostats, pressure controls, humidistats, motor-operated valves, temperature regulators, motor operators, unit ventilator controls, hot water controls, electronic controls, control centers, and accessories.—Barber-Colman Co., 1300 Rock St., Rockford, Ill.

For more information circle **294** on inquiry card.

PROCESS INSTRUMENTATION. 8-page Bulletin 100-R5 contains operational data and design feature descriptions of twelve varied products for positive control of materials in motion. Included are Dall flow tubes, venturi tubes, venturi flow nozzles, venturi insert nozzles, Chronoflo telemeters, transistorized Synchro-Scan systems, rubber-seated butterfly valves, pneumatic valve positioners, Shuntflo flow meters, Propeloflo positive displacement meters, Conveyoflo meters for dry materials, and visible-flow chlorinizers.—B-I-F Industries, Inc., 345 Harris Ave., Providence 9, R. I.

For more information circle **295** on inquiry card.

LIGHT CONTROL. 4-page Bulletin PA 569, entitled "Photoswitch Light Control" contains descriptive data on new automatic on-off control for any lighting system whose operation should be keyed to outdoor light conditions.—Photoswitch Div., Electronics Corp. of America, One Memorial Dr., Cambridge 42, Mass.

For more information circle **296** on inquiry card.

MOTORS

SERVO MOTOR. 2-page leaflet details full specifications and data on new 60 cycle Miniature Servo Motor, Model M-100, which reaches full speed of 1460 rpm 0.004 sec.—Dynamic Instrument Corp., 59 New York Ave., Westbury, L. I., N. Y.

For more information circle **297** on inquiry card.

FHP MOTORS. 8-page bulletin describes and illustrates in detail the construction of a-c and d-c Type "N" fhp motors, available in three basic sizes.—Bodine Electric Co., 2500 W. Bradley Pl., Chicago 18, Ill.

For more information circle **298** on inquiry card.

MOTOR BRAKE. 2-page Specification Sheet 3202 describes Style UH 70 Series magnetic disc brake for use in Class 1, Group D, hazardous locations, which automatically sets in case of power failure.—Stearns Electric Corp., Milwaukee 2, Wisc.

For more information circle **299** on inquiry card.

ENVIRONMENTAL

SOUND GENERATORS. 2-page Leaflet TI/4 contains specifications of Hi-Intensity Sound Generators Models TI 450-5/5 and IT 150-24/24, the latter digits indicating size in inches.—Transducer, Inc., 2957 Honolulu Ave., La Crescenta, Calif.

For more information circle **300** on inquiry card.

VIBRATION STUDY. 4-page bulletin describes and explains uses of Model 103A Slip-Sync, a unit which provides completely automatic synchronization of stroboscopic lights for watching shake tests in slow motion.—Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.

For more information circle **301** on inquiry card.

MOBILE CONSOLES. 4-page bulletin describes modular mobile consoles which provide protection against shock and vibration, plus ventilation for electronic equipment.—Esco Engineering Co., P. O. Box 184, Broadview, Ill.

For more information circle **302** on inquiry card.

VALVES, ACTUATORS

ACTUATOR PACKAGE. 2-page Data Sheet WF 1394 describes solenoid-controlled actuator package Model 106-2 for hydraulic and pneumatic applications featuring extremely low leakage—even with Helium. Pressures range up to 3,000 psig.—Waldorf Fluid Systems Div., Waldorf Instrument Co., Huntington Station N. Y.

For more information circle **303** on inquiry card.

WHAT MAKES THE DIFFERENCE?

In producing ultra-critical and non-critical elements, customized to your specifications, Plummer and Kershaw's AUTOMATIZED production brings to you the finest precisioned optics in the field.

PLUMMER AND KERSHAW has an established reputation for outstanding reliability, superior quality and accuracy at lowest cost.

Feel free to call on us to help you solve your particular problem.

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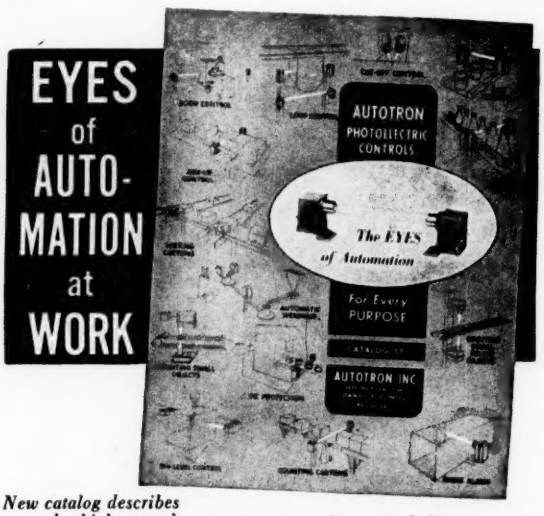
Request Bulletin 737 on your Letterhead

For more information circle **104** on inquiry card.



New catalog describes normal, high speed, ultra sensitive and impulse actuated photoelectric controls with safety relays, warm up protection, etc. Also photoelectric timing controls, and wide seletcion of light sources with many protective features.

Send for your personal copy

Applications shown include automatic control of conveyors, inspection, carton sorting, smoke and fire detection, die protection, counting, weighing, limit control, tension control, car washing control, piling to exact count, safety control, conveyor traffic and jam-up control, timing control, control of spraying equipment, ramp traffic control and others.

AUTOTRON, INC.

3629 North Vermillion

Box 722QW Danville, Ill.

Representatives in Principal Cities

For more information circle **105** on inquiry card.

INSTRUMENT VALVES. 4-page Data Unit 302 gives features, application information, pressure-temperature ratings, and specifications of valves for instrument piping and general use.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

For more information circle **304** on inquiry card.

VALVE SPECIALISTS. Binder contains several 2- and 4-page bulletins on rotary-stem and slip-stem regulating, transfer and internal-pilot control valves; vacuum breakers; liquid level controllers; and by-passes.—Alcor Valve Specialties Co., Pleasantville, N. J.

For more information circle **305** on inquiry card.

MIDGET VALVES and fittings are described in 8-page Catalog 658. Working pressure range from 10,000 through 60,000 psig, and connections are for $\frac{1}{16}$" and $\frac{1}{8}$" tubing, and $\frac{1}{8}$" and $\frac{1}{4}$" NPT.—High Pressure Equipment Co., 1222 Linden Ave., Erie, Pa.

For more information circle **306** on inquiry card.

SERVO VALVES. 6-page Catalog 210 contains a series of curves and schematics which highlight design and performance characteristics of Series 21 low-flow servo valves for precise control at high power levels. Contains glossary of servo valve terms.—Moog Valve Co., Inc., Proner Airport, East Aurora, N. Y.

For more information circle **307** on inquiry card.

TEMPERATURE

RESISTANCE THERMOMETERS. 36-page Catalog EN-S4, contains complete information on Thermohm detectors for temperatures up to 1000°F. Applications in the fields of ceramics, chemicals, food and rugs, glass, metalworking, petroleum and refining, steam and power generation are described.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

For more information circle **308** on inquiry card.

TEMPERATURE INDICATORS. 2-page Bulletin 4001 provides details on Dual Range Therm-O-Meter Model 389-3L. Low range is from −50°F to 100°F. high range from 100°F to 250°F for separate readings through one selector switch.—Simpson Electric Co., 5200 West Kinzie St., Chicago 44, Ill.

For more information circle **309** on inquiry card.

INCONEL SHEATHING on thermocouples and conductors, and its applications are explained in 4-page bulletin.—Tuttle & Kift, Industrial Dept., 1823 N. Monitor Ave., Chicago 39, Ill.

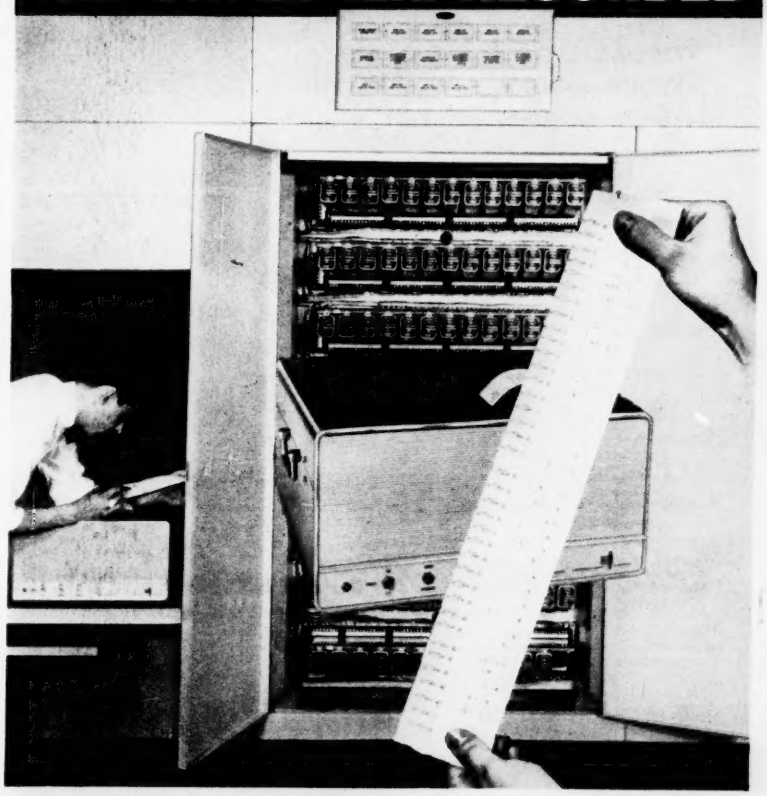
For more information circle **310** on inquiry card.

THERMISTORS. Five 4-page folders "Meet the VECO Thermistor" present the story of the growth of thermistors applications. Contain illustrations, circuit diagrams, tables and charts.—Victory Engineering Corp., 537 Springfield Rd., Union, N. J.

For more information circle **311** on inquiry card.

SHEATHED THERMOCOUPLES, etc. 4-page brochure provides specifications of Con-O-Pak thermocouples, extension wires, and heating elements im-

OFF-NORMAL CONDITIONS REPORTED and RECORDED



NEW PANELLIT RECORDING ANNUNCIATOR UNCOVERS PROFIT LEAKS

- **Pinpoints temperature, flow, pressure and level process trouble areas by accurately, instantly recording off-normal operations.**
- **Permanent, unalterable statistical data helps prevent downtime repetition.**
- **No time-wasting decoding. Directly readable digital form.**

Typical power station application: The exact time period of steam stop valve closure, generator circuit breakers and overspeed trip resets is permanently recorded, providing advance notice of sluggish functioning and permitting immediate preventive action.

Model RA helps attain highest quality products by continuously monitoring all process variables. Also helps reduce downtime, maintenance and operating costs in your plant.

Write for Bulletin 102 today.

PANALARM®

PANELLIT, INC.

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For more information circle **106** on inquiry card.

GAS ANALYSIS BY THERMAL CONDUCTIVITY SINCE 1935

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GOW-MAC
HIGH POSITIVE COEFFICIENT RESISTANCE FILAMENTS

For Repair, Experiment and Instruction in

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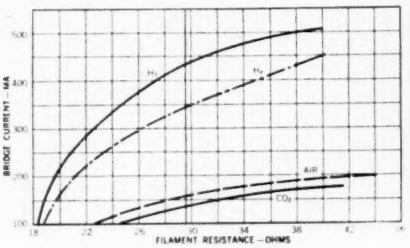
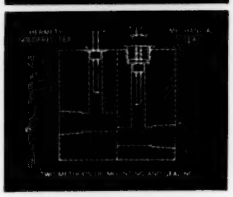
TYPE 9225 FILAMENTS (AVAILABLE IN MATCHED PAIRS) AMBIENT RANGE: —250° TO OVER 300°C.





METAL	FORM	RESISTANCE (OHMS) COLD	RESISTANCE (OHMS) OHMIC	CURRENT IN MA AT ROOM TEMPERATURE WILL MAKE D.C.	PRICE PER PAIR
TUNGSTEN	HELIX	20	30	150	$10.00
TUNGSTEN (GOLD PLATED)	HELIX	18	27	150	20.00
KOVAR (ALLOY OF NICKEL COBALT, IRON)	STRAIGHT	4	7	200	18.00

TUBE NUTS AVAILABLE. CAT. No. 9611 (Brass)... Price Per Pair .50
*Minimum order $50.00

Other Gow-Mac Products
- Portable and Panel Instruments
- Power Supplies (400 ma. D.C.)
- Thermal Conductivity Cells (Hot Wire and Thermistor)

Order for immediate shipment or send for Bulletin FIL. Address Department. IA.

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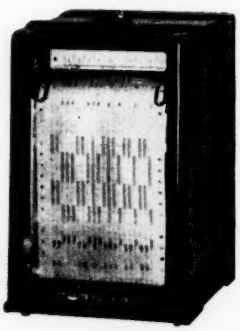
For more information circle **107** on inquiry card.

ARE THESE PROBLEMS BOTHERING YOU?

- Productive and idle time?
- Flow of materials?
- Position of gates and dampers?
- Time of failure in life tests?
- Length of phone calls?
- Sequence of switching?
- Timing of events?



The operation recorder will obtain the answers to these problems, and many more, for you. An instrument with 20 pens writing on a moving chart, the operation recorder shows:

- *When events occur*
- *How long they last*
- *How frequently they occur*
- *The relationship of a series of events to each other*

Ask for Catalog Section 50

"The Meter With a Record" For Over 50 Years

The ESTERLINE-ANGUS Company, Inc.
Pioneers in the Manufacture of Graphic Instruments
Dept. G, P. O. Box 596, INDIANAPOLIS 6, INDIANA

For more information circle **108** on inquiry card.

NEW LITERATURE

bedded in magnesia oxide and sheathed in either Inconel, aluminum, copper or 4 types stainless steel.—Continental Sensing, Inc., 1950 North Ruby St., Melrose Park, Ill.

For more information circle **312** on inquiry card.

FLOW, PUMPS, LEVEL

MAGNETIC FLOW METERS for 1/10 and $\frac{3}{8}$-inch lines are described in 2-page bulletin 20-14C which also outlines typical "difficult" liquids which can be measured.—The Foxboro Co., Foxboro, Mass.

For more information circle **313** on inquiry card.

ELECTROMAGNETIC PUMP. 4-page Bulletin EP-2 presents description, principle of operation, performance curves, and application of a-c conduction-type electromagnetic pumps.—MSA Research Corp., Callery, Penna.

For more information circle **314** on inquiry card.

FLOW CONTROL VALVE providing infinite-variable multi-range control for hydraulic fluids with operating pressures to 2000 psig, available in 2-port or 3-port types is described with specifications and hydraulic-circuit diagrams in 6-page Bulletin 143A.—Denison Engineering Div., American Brake Shoe Co., 1160 Dublin Rd., Columbus 16, Ohio.

For more information circle **315** on inquiry card.

FLOW REGULATORS. 16-page Catalog 1000 describes pressure-compensated flow regulators for hydraulic power systems most of them rated at 3000 psig with guaranteed controlled flow rates from 0.1 to 100 gpm.—Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.

For more information circle **316** on inquiry card.

ROTAMETERS. 4-page Bulletin 18B describes bypass rotameters for 2" and larger pipelines. Contains instructions for determining permanent pressure loss across main orifice, and required straight run of pipe before and after main orifice.—Schutte and Koerting Co., Dept. M-I, Cornwells Heights, Bucks County, Penna.

For more information circle **317** on inquiry card.

LEVEL RECORDER/CONTROLLER. Details of probe-type capacitance-null balance recorder-controller-indicator Pneutronic Series 42R-F are given in 2-page Bulletin RF-588. Control is electrical or pneumatic. Operates with conductive or non-conductive materials.—Aeronautical & Instrument Div., Robertshaw-Fulton Controls Co., 401 N. Manchester, Anaheim, Calif.

For more information circle **318** on inquiry card.

MOISTURE

PROCESS MOISTURE MONITOR. 4-page Bulletin 1845A describes the Type 26-310, an explosion-proof instrument for continuous measurement of moisture in process streams.—Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

For more information circle **319** on inquiry card.

CONDENSIFILTERS. 4-page Bulletin 4158 describes and illustrates Models M-100-T and M-30-T Condensifilters for filtering and dehydrating compressed air and gases.—Hankison Corp., College & Pike, Canonsburg, Penna.

For more information circle **320** on inquiry card.

VAPOR ADSORPTION. 10-page Bulletin SC-1047 describes Vape-Sorbers for hydrocarbon removal to provide clean, dry air and gas for hospitals, pharmaceutical or chemical manufacturers, instruments, etc.—Selas Corp. of America, Dresher, Penna.

For more information circle **321** on inquiry card.

ANALYTICAL, LABORATORY

NEPHELOMETERS are detailed in 8-page Bulletin B-246. Used to measure and control the clarity of beverages and other liquids, pharmaceuticals, industrial fluids, contaminants in water and bacterial growth rates, they can detect and measure Calcium, Magnesium, Sulfates, Chlorides or similar ions in trace amounts without filtering, drying or weighing.—Coleman Instruments Co., 318 Madison St., Maywood, Ill.

For more information circle **322** on inquiry card.

X-RAY POLYCHROMATOR. 4-page "Spectrographers' News Letter," Vol. XI, No. 3., contains description of the PXQ, a direct-reading X-ray polychromator which is basically a production-control quantometer.—Applied Research Laboratories, Inc., P. O. Box 1710, Glendale 5, Calif.

For more information circle **323** on inquiry card.

GAS-VAPOR CHROMATOGRAPHY. 8-page Bulletin No. 838 discusses column temperature, retention time, detector temperature, resolution, and temperature programming.—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

For more information circle **324** on inquiry card.

CHROMATOGRAPHY. 4-page bulletin on "A New Dimension in Paper Chromatography" shows how tests which formerly required hours are now made in 5 min.—Precision Scientific Co., 3737 West Cortland St., Chicago 4, Ill.

For more information circle **325** on inquiry card.

ACID-RESISTANT WARE. 20-page Catalog G358 covers polyethylene and nylon products for laboratories and industry.—General Scientific Equipment Co., 7516 Limekiln Pike, Phila. 50, Pa.

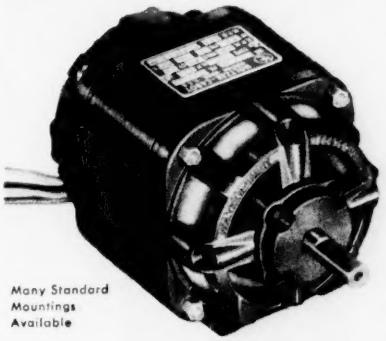
For more information circle **326** on inquiry card.

NUCLEONICS

SURVEY METER. 2-page Technical Bulletin N-29 provides details on Sentinel, a lightweight, portable, battery-operated meter for general purpose survey work in radioisotope laboratories etc. which offers choice of beta-gamma and/or alpha-beta-gamma probes.—Nucleonic Corp. of America, 196 Degraw St., Brooklyn 31, N. Y.

For more information circle **327** on inquiry card.

New Designs in Motors from HOLTZER-CABOT



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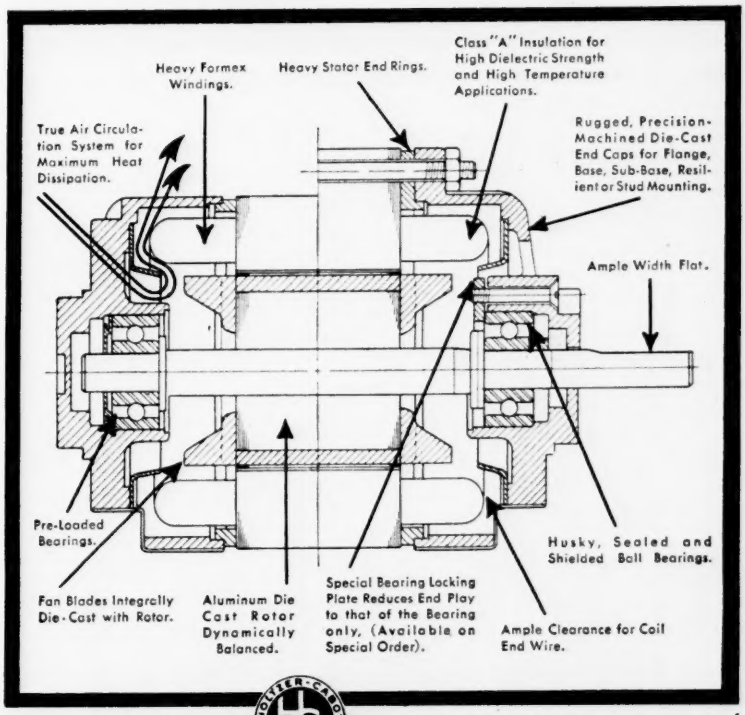
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For more information circle **109** on inquiry card.

NEW LITERATURE

IONIZATION GAGE. Leaflet describes Control Circuit Type BD-20C.—Bon-De Electronic Labs., Inc., Danvers, Mass.

For more information circle **328** on inquiry card.

OPTICAL

ULTRASPEED CAMERA. 2-page bulletin provides information on the 1,000,000-frames/sec Model UC-1.—Dynamic Measurements Corp., 40 So. Los Robles Ave., P. O. Box 4067, Pasadena, Calif.

For more information circle **329** on inquiry card.

POLARIMETRIC ADAPTER. 2-page Bulletin 330 describes adapter for Lumetron Photoelectric Polarimeter Model 402-EP affording polarimetric measurements.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

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DATA HANDLING

COMPUTATION CENTER. 4-page brochure provides information on operation, equipment, kind of problems solved, and charges made by Los Angeles Computation Center.—Beckman/Berkeley Div., 305 Parkman Ave., Los Angeles 26, Calif.

For more information circle **331** on inquiry card.

CONTROL COMPUTER. 4-page brochure contains description of transistorized RW-300 Digital Control Computer, and discussions of process control, data logging, pilot plant, and test facility applications for computer control systems.—The Thompson-Ramo-Wooldridge Products Co., P. O. Box 45067, Airport Station, Los Angeles 45, Calif.

For more information circle **332** on inquiry card.

GRAPHICAL REPRESENTATION. 28-page binder describes graphical representation with the Univac 120 with five examples of graphs.—Remington Rand Univac, Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

For more information circle **333** on inquiry card.

FREQUENCY-RESPONSE SLIDE RULE. 16-page manual describes and explains uses of special imported slide rule for frequency-response computations.—Frederick Post Co., 3650 Avondale, Chicago 18, Ill.

For more information circle **334** on inquiry card.

ELECTRONIC COMPUTERS. 6-page brochure details how the ECM electronic computing machine performs many of the functions of the complicated computers while offering simplicity of operation..—Clary Corp., 408 Junipero St., San Gabriel, Calif.

For more information circle **335** on inquiry card.

ANALOG-PUNCHED TAPE SYSTEM. 4-page data sheet describes Model ZA-750 Analog-Punched Tape Data System.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

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DATA CONVERSION. 6-page bulletin presents modularized Transicon Datrac units for analog-to-digital, and

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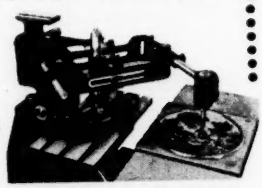

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digital-to-analog conversion, also alarm limit monitoring.—Epsco Inc., Equipment Div., 588 Commonwealth Ave., Boston 15, Mass.

For more information circle **337** on inquiry card.

RECORDING

X-Y RECORDER. 4-page folder contains physical and operational specifications, also circuit diagrams of portable model 1100D Variplotter for pen-and-ink graphs.—Electronic Associates, Inc., Long Branch, N. J.

For more information circle **338** on inquiry card.

OSCILLOGRAPHS and amplifiers are detailed in 8-page Bulletin 210 giving engineering specifications, electrical characteristcs, and construction of direct-writing instruments and associated amplifiers.—Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio

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ANNUNCIATORS

ANNUNCIATOR. 4-page Bulletin 103 describes completely-integrated, space-saving, Panalarm Series 61 annunciator, featuring lower installation cost, flashing sequence alarm, and no-drain-circuit for monitoring from 24 to 96 points in the utility and continuous process industries.—Panellit, Inc., 7401 No. Hamlin Ave., Skokie, Ill.

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INDICATING LIGHTS. 4-page Catalog A-58 describes in detail complete line of Color-Lite sub-miniature incandescent indicating lights and accessories. —The Sloan Co., 4101 Burbank Blvd., Burbank, Calif.

For more information circle **341** on inquiry card.

TESTING, GAGING

UNIVERSAL TESTER. 6-page Bulletin 9E describes multi-low-range universal tester, a small, compact motorized laboratory instrument that quickly makes accurate tests in tensile, compression, tranverse and shear on any low-strength industrial material, operating on the principle of a calibrated pendulum.—W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.

For more information circle **342** on inquiry card.

TESTING EQUIPMENT for soils, concrete and asphalt are described in a New Products Bulletin.—Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

For more information circle **343** on inquiry card.

HIGH-POTENTIAL TESTING. 4-page bulletin 5-1.2 details full specifications and application data of some 15 d-c Hypot models covering output ranges of 5, 10, 20 and 30 KV dc for design, production and maintenance testing of cables, motors, capacitors and insulation samples.—Associated Research, Inc., 3777 West Belmont Ave., Chicago 18, Ill.

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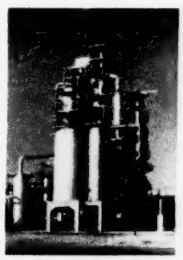

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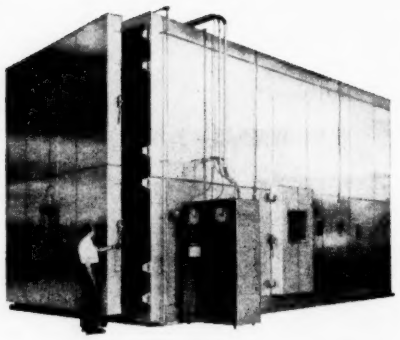
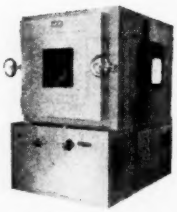
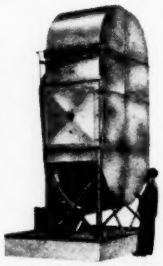


American Research's unique experience in the design and development of test equipment for the most difficult parameters and stringent specifications makes it possible for them to provide you with any type of environmental test chamber to meet your most advanced requirements. Frequently they have already solved similar problems for others. And every American Research chamber incorporates the latest features of testing efficiency and dependability.

Any size test chambers are available from American Research. Room shown above permits a large truck to deliver the test item to the interior without double handling. Components or completed items can be tested through a complete range of simulated environments.



Altitude chambers in any size — Altitude 200,000' or higher; temperature +500°F and higher to −100°F and lower; Humidity 20% to 95%.



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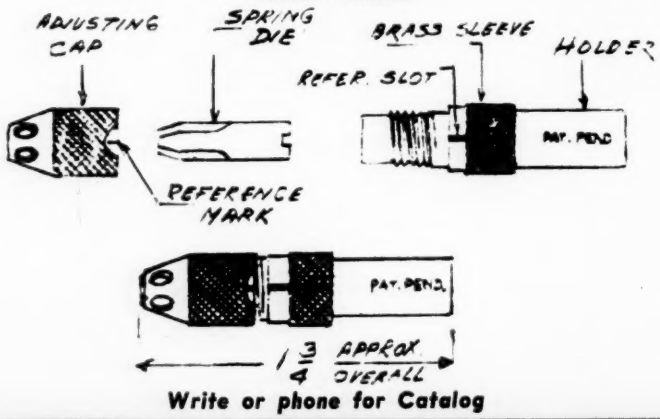

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NEW LITERATURE

OPTICAL GAGING. 114-page General Catalog 10 comprises information on optical gaging, chart-gages and fixturing.—Optical Gaging Products, Inc., 26 Forbes St., Rochester 11, N.Y.
For more information circle **345** on inquiry card.

SPHEROMETER. 4-page brochure illustrates and describes two ball-point spherometers, Models L-1 and P-1,, for laboratory and shop measurements respectively, of spherical surface radii.—Penn Optical and Instrument Co., 19642 Bristol St., P. O. Box 68, Costa Mesa, Calif.
For more information circle **346** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

TRANSISTOR SERVO AMPLIFIERS. 2-page Bulletin No. 501-2 reviews complete performance specifications, also application data of Model 501-2 particularly suited for controlling small servo motors in high-performance instrument control systems.—Librascope Inc., 808 Western Ave., Glendale 1, Calif.
For more information circle **347** on inquiry card.

TRANSFORMERS. 4-page brochure lists many new types of transistor power supply, driver, output, low level chopper input, and dc/dc converter transformers. Typical schematic and circuit diagram are also shown in conjunction with converter transformers.—Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N. Y.
For more information circle **348** on inquiry card.

PACKAGED AMPLIFIER. Tentative data on the new UPA-2 Utility Packaged Amplifier are contained in 16-page booklet. General-purpose utility package is designed for use computer-type operations in industry and in industry and in laboratory instrumentation.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.
For more information circle **349** on inquiry card.

SELENIUM RECTIFIER. 4-page booklet gives complete listing of continuous d-c amp ratings for 26, 33, 36, 40, 45 and 52 volt RMS vacuum-process Selenium Rectifier Cells. Also gives specifications for 20 cell sizes from one in sq to 12" x 16".—Syntron Co., 669 Lexington Ave., Homer City, Penna.
For more information circle **350** on inquiry card.

SWITCHES, RELAYS

SEALED RELAYS. 24-page 1958/59 Catalog GEA-6628 offers information on hermetically sealed relays. Contains circuit diagrams, coil data, and specifications for micro-miniature, subminiature, miniature, and high-speed relays.—General Electrical Co., Schenectady 5, N. Y.
For more information circle **351** on inquiry card.

MERCURY SWITCHES. 4-page brochure describes the twelve most popular styles of mercury switches available from American Designed Components, Inc., Jericho, L. I., N. Y.
For more information circle **352** on inquiry card.

ELECTROMAGNETIC RELAYS. 132-page booklet contains 33 papers by 42 authors presented at the Sixth National Conference on Electro-Magnetic Relays at Oklahoma State University. Subjects like shock testing micro-miniature relays, vacuum relays, reliability problems and contact resistance are discussed.—Potter & Brumfield, Inc., Princeton, Ind.

For more information circle **353** on inquiry card.

SNAP-ACTING SWITCHES. 32-page Catalog 62c features significant innovations in basic switches for industrial and commercial applications.—Micro Switch, a Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

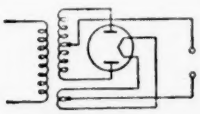
For more information circle **354** on inquiry card.

RELAYS. 68-page catalog lists many thousand relays by types or applications, and by manufacturers. Gives specifications and prices.—Relay Sales Inc., Box 186, West Chicago, Ill.

For more information circle **355** on inquiry card.

PROXIMITY SWITCH. 2-page bulletin presents information on non-contact unit for detecting steel objects, and control of magnetic shield pilers.—Bucciconi Engineering Co., Inc., 899 Grant St., Gary, Ind.

For more information circle **356** on inquiry card.



POWER SUPPLIES

POWER SUPPLIES. 6-page folder-type catalog covers transistorized inverters and converters, Transpac miniaturized power packs; power supplies for transistor applications, transistorized units for high current, and d-c transistorized frequency changers, and related models.—Electronic Research Associates, Inc., 67 Factory Place, Cedar Crove, N. J.

For more information circle **357** on inquiry card.

POWER SUPPLIES, etc. 16-page Catalog 1958 contains illustrations and descriptions of power supplies (tubeless, electronic, high voltage for dc), also a-c regulators, insulation testers, and meters.—Sorensen & Co., Richards Ave., South Norwalk, Conn.

For more information circle **358** on inquiry card.

POWER SUPPLIES. 2-page Bulletin, VP-858 illustrates and describes two new variable frequency power supplies VP-410 and VP-1000 and briefly lists a number of typical applications for the units.—Empire Devices Products Corp., Amsterdam, N. Y.

For more information circle **359** on inquiry card.

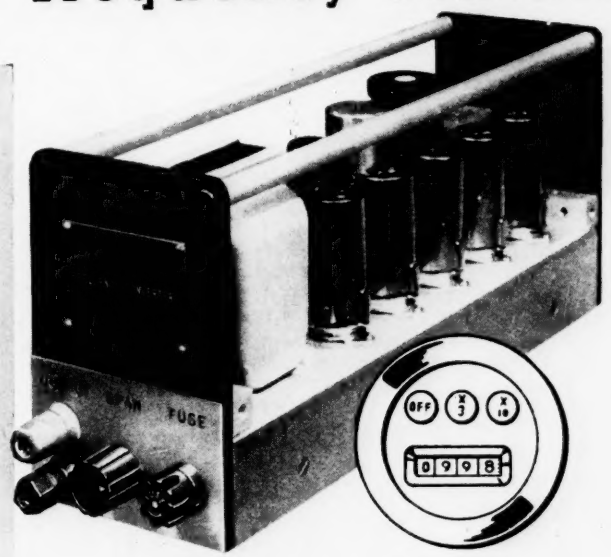
A-C VOLTAGE SUPPLY. 8-page Circular CVL-274 describes AC Solavolt, which is a hormonic-free constant voltage transformer (static-magnetic regulator) with the addition of an adjustable autotransformer.—Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.

For more information circle **360** on inquiry card.

POWER SUPPLIES. 4-page Catalog 858 contains information on d-c power packages, selenium rectifiers, rectifier transformers, components.—Technical Apparatus Builders, 109 Liberty St., New York 6, N. Y.

For more information circle **361** on inquiry card.

new cox frequency converter



The new Cox Frequency-to-Analog Converter joins the ever growing list of precision instruments designed and built for electronic data handling by the Cox Instruments Division — pioneers in precision flow measuring equipment.

The Type 2 Converter was originally developed for use with the Cox Turbine Flow Measuring System, but is now being widely used in many other applications for extremely linear conversions in telemetering, computers and other transducer-recorder systems. Its high sensitivity, excellent stability and fast transient response combined with low cost, make it an outstanding converter for all around use.

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SPECIFICATIONS

Range	100 to 5000 cps (other ranges available)
Linearity	.1 per cent over 10:1 range
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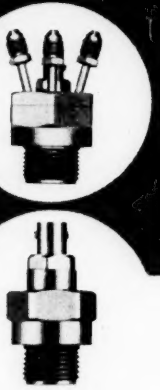

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MAF-6	400	5	57.5	1.2	0.4
	400	10	57.5	1.6	0.6
MAF-7	400	15	57.5	2.5	1.0

PUSH-PULL MAGNETIC AMPLIFIERS

Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. KΩ
MAP-1	60	5	115	1.2	1.2
MAP-2	60	15	115	1.6	2.4
MAP-3	60	50	115	2.0	0.5
MAP-3-A	60	50	115	7.0	2.9
MAP-4	60	175	115	8.0	6.0
MAP-7	400	15	115	0.6	2.8
MAP-8	400	50	110	1.75	0.6

All units designed for 115V-AC operation

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ELECTRICAL, ELECTRONIC COMPONENTS

PRECISION POTENTIOMETERS. incremental stepping motors and synchros, and pressure switches are detailed in new 4-page brochure.—G. M. Giannini & Co., Inc., 918 East Green St., Pasadena, Calif.

For more information circle **362** on inquiry card.

CABLE SHIELDING. 2-page Data Sheet 140 illustrates and describes new bi-directional Netic Co-Netic foil strips for magnetically and electrostatically shielding telephone and other communication cables.—Magnetic Shield Div. Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.

For more information circle **363** on inquiry card.

ULTRASONIC DELAY LINES. 4-page bulletin contains descriptions and specifications of variable, and solid ultrasonic delay lines, as well as company's manufacturing facilities.—Andersen Laboratories, Inc., 501 New Park Ave., West Hartford, Conn.

For more information circle **364** on inquiry card.

CHOPPERS. In a series of new pamphlets on choppers, entitled "The Contact Modulator", "Why Use Choppers?" is the first one to be available.—The Airpax Products Co., Seminole Div., Ft. Lauderdale, Fla.

For more information circle **365** on inquiry card.

DYNAMIC DIGITAL MODULES. 8-page Supplement A to Catalog T provides descriptive information and technical specifications on new transistorized T-Pac one-megacycle circuit units.—Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass.

For more information circle **366** on inquiry card.

DECADE INDUCTORS. 4-page brochure contains description, applications, specifications, and technical data on high-Q, low-frequency precision units.—Computer Engineering Associates, Inc., 350 North Halstead, Pasadena, Calif.

For more information circle **367** on inquiry card.

TRANSISTOR FILTERS. Catalog sheet covers descriptive material on transistor transient filters which connected at the d-c input of transistorized inverters-converters, frequency changers and switching circuitry eliminate line conducted transients to the circuits and spurious noise transmission to the line.—ERA Electric Corp., 67 East Centre St., Nutley, N. J.

For more information circle **368** on inquiry card.

TANTALUM CAPACITORS. 2-page Form F-1126 contains description and tabulated specifications, ratings and ordering references of Blu-Cap tantalum capacitors.—Fansteel Metallurgical Corp., Rectifier-Capacitor Div., North Chicago, Ill.

For more information circle **369** on inquiry card.

ELECTRONIC HARDWARE. 72-page Reference Manual No. 85 presents information on standard electronic hardware such as binding posts, mounting brackets, grommets, phone tip and sub-miniature jacks, pilot light and toggle switch shields, terminals and terminal strips, and many others. Contains also tables with engineering data.—Amatom Electronic Hardware Co., Inc., 88 Drake Ave., New Rochelle, N.Y.

For more information circle **370** on inquiry card.

CRYSTAL FILTERS. 4-page Technical Bulletin 10.7 on the new family of crystal filters shows vacuum tube and transistor circuitry, pulse and impulse response photographs, attenuation vs frequency curves, and block diagrams. —Hycon Eastern, Inc., 75 Cambridge Parkway, Cambridge, Mass.

For more information circle **371** on inquiry card.

PLUG-IN CIRCUITRY. 4-page Brochure 11878 provides descriptive information on transistorized plug-in binary counters.—The Walkirt Co., 141 West Hazel St., Inglewood 3, Calif.

For more information circle **372** on inquiry card.

INDUSTRIAL TUBES. 30-page "flip-style" Chart T-24 shows electrical and physical characteristics of electron tubes, and gives technical information pertinent to each type within the class. —Tung-Sol Electric Inc., 95 Eighth Ave., Newark 4, N. J.

For more information circle **373** on inquiry card.

CONNECTORS

CONNECTORS. 2-page bulletin gives specification, outline dimensions and general information on new Series C-18 hexagonal connectors available in four, five and seven contacts,—DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information circle **374** on inquiry card.

MULTIPLE CONNECTORS. 4-page bulletin on Series DTX Rack and Panel connectors illustrates nineteen contact arrangements.—H. H. Buggie, Inc., Box 817, Toledo 1, Ohio.

For more information circle **375** on inquiry card.

MECHANICAL COMPONENTS

GEARED MECHANISMS. 6-page Bulletin No. 102-58 describes predesigned mechanisms and components for the servo and instrument fields.—Precision Mechanisms Corp., 577 Newbridge Ave., East Meadow, L. I., N. Y.

For more information circle **376** on inquiry card.

PRECISION COMPONENTS, produced by European craftsmen, including screw machine parts, hair springs, spindles and shafts, stampings, name plates and dials, pinions, and jewels, are contained in catalog.—American Laubscher Corp., 250 W. 57th St., New York 19, N. Y.

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BERYLLIUM COPPER SPRINGS, etc. 20-page Catalog No. 10 covers compression springs, flat springs, strip springs, contact rings, contact strips and screw machine products, fabricated of beryllium copper.—Instrument Specialties Co., Inc., 231 Bergen Blvd., Little Falls, N. J.

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STAMPINGS. 4-page Bulletin 101 details services in fabrication and production of stampings from rare and specialized metals with quick-reference chart on their properties and uses.—Staver Co., Inc., N. Saxon Ave., Bay Shore, N. Y.

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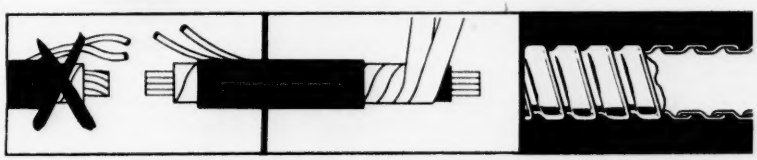

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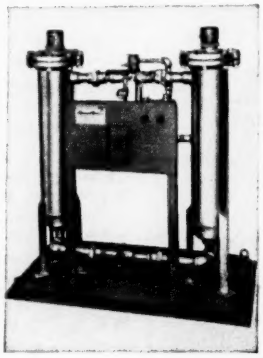

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NEW LITERATURE

PRECISION GEARS, etc. 10-page folder contains descriptive literature of company's 3 divisions manufacturing fine-pitch gears; high-precision gears and gear systems; and speed measuring equipment, respectively.—Geartronics Corp., 50 Nashua St., Woburn, Mass.
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FINE-PITCH GEARS. 4-page bulletin presents information on products, including gear assemblies.—Pickup Precision Gear Co., 1926 Placentia Ave., Costa Mesa, Calif.
For more information circle **381** on inquiry card.

NYLON BEARINGS. 8-page brochure, Form 209, describes advantages of Nylon bearings and lists available types of Snap-In Nyliners which can be used without lubrication.—Thomson Industries, Inc., Manhasset, L. I., N. Y.
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MATERIALS

METAL CHARTS. Two new charts, one showing melting points of metals, (in F and C scales) from tungsten to mercury; the other showing densities of metals, ranging from osmium to lithium, can be requested on company letterheads.—Metals and Fabrication Div., Fansteel Metallurgical Corp., North Chicago, Ill.
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PRINTED CIRCUIT MATERIAL. Copper-clad plastic laminates for electronic printed circuits are subject of Data Sheet 8-1.—Taylor Fibre Co., Norristown, Penna.
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METALLIZING PAINTS. 4-page Bulletin S-62 describes new metallic paint for printed circuits, applicable on ceramics, titanates, glass, mica and other inorganic materials in a range of firing temperatures.—Western Gold and Platinum Co., Belmont, Calif.
For more information circle **385** on inquiry card.

EPOXY GLASS LAMINATES. 21-page technical data manual contains test values, curves, and specs, on epoxy glass copper clad and unclad laminates for printed circuitry.—The Mica Corp., 4031 Elenda St., Culver City, Calif.
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CEMENTABLE TEFLON TAPES. 4-page Bulletin CT-58 gives essential technical data for glass-supported, unsupported and metal-clad cementable Teflon sheets and tapes.—Continental-Diamond Fibre Co., (subsidiary of Budd Co.), Newark, Del.
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FABRICATION FACILITIES

INDUSTRIAL DIE-CAST PARTS, etc. 10-page bulletin covers variety of zinc-alloy die-cast and molded thermoplastic products, made to customer's specifications, and/or available from stock.—Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.
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TRANSISTOR PRODUCTION. 6-page booklet, "an Analog Computer Study of the Stability of a Molten Zone Refining Process used in the Production of Transistors," describes technique of simulating on the analog computer conditions experienced by germanium rod under various conditions of temperature, rod dia., and length of molten zine.—Electronic Associates, Inc., Long Branch, N. J.

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INSTRUMENT PANELS. 6-page bulletin describes fabrication of modular panel sections, racks and cabinets, cubicles, consoles and graphic panels. —Falstrom Co., 154 Falstrom Court, Passaic, N. J.

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FACILITIES. 30-page brochure entitled "The Fenwal Spectrum" describes facilities for design and manufacture of temperature controls, detectors and indicators.—Fenwal Inc., Ashland, Mass.

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OPTICS. 16-page brochure describes facilities for research, development, design and manufacture of high-quality optics for instrument manufacturers in geophysical, industrial, aeronautical and military fields.—Spectron/Transducer Div., Consolidated Electrodynamics, 1725 Primrose Ave., Monrovia, Calif.

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MISCELLANEOUS

FOLDING MACHINE. 10-page Publication 144 is an operations and service manual for machine which folds long strips or rolls of paper such as charts from oscillographs or recorders.—Benson-Lehner Corp., 11930 W. Olympic Blvd., Los Angeles 64, Calif.

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PACKAGED LABORATORIES. 4-page Bulletin 6 describes environmental test equipment for mass-testing of production components.—Wyle Associates, 128 Maryland St., El Segundo, Calif.

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BENCH BLOCK. 36-page catalog lists complete line of watchmakers' and instrument makers' tools including No. 1086-A bench block.—Kendrick & Davis Co., 10 Water St., Lebanon, N. H.

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PERIPHERAL MARKING MACHINES for hot stamping of calibrations and other markings are described in new 6-page catalog 9A.—The Acromark Co., 9-13 Morrell St., Elizabeth 4, N. J.

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PLASTIC BINDING. 18-page booklet "A New APECO Product for Your Office," describes plastic binding for office paperwork, and pictures the Bindak punching and binding units available.—American Photocopy Equipment Company (APECO), Plastics Div., 2100 W. Dempster St., Evanston, Ill.

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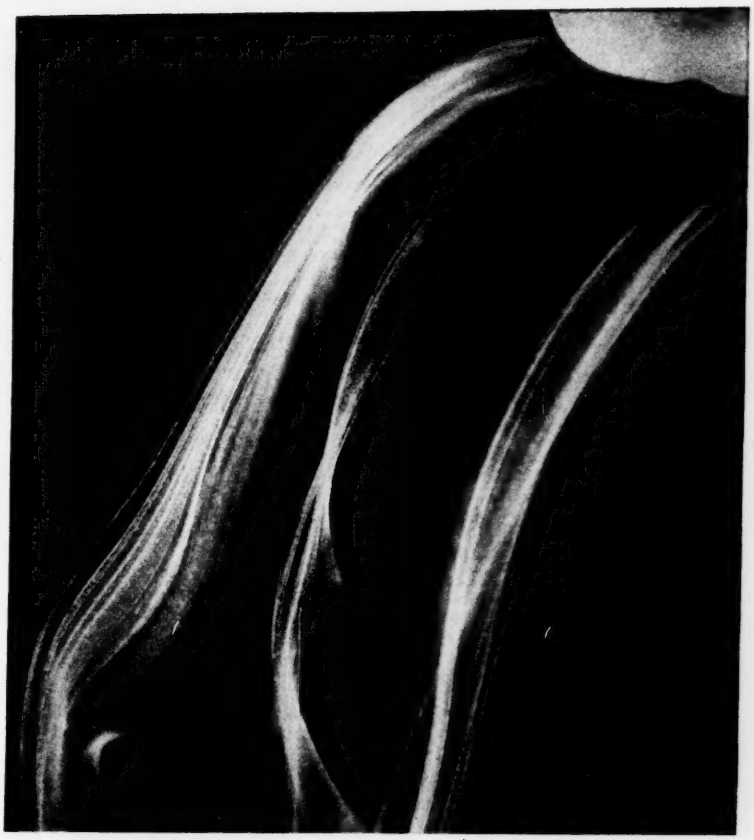

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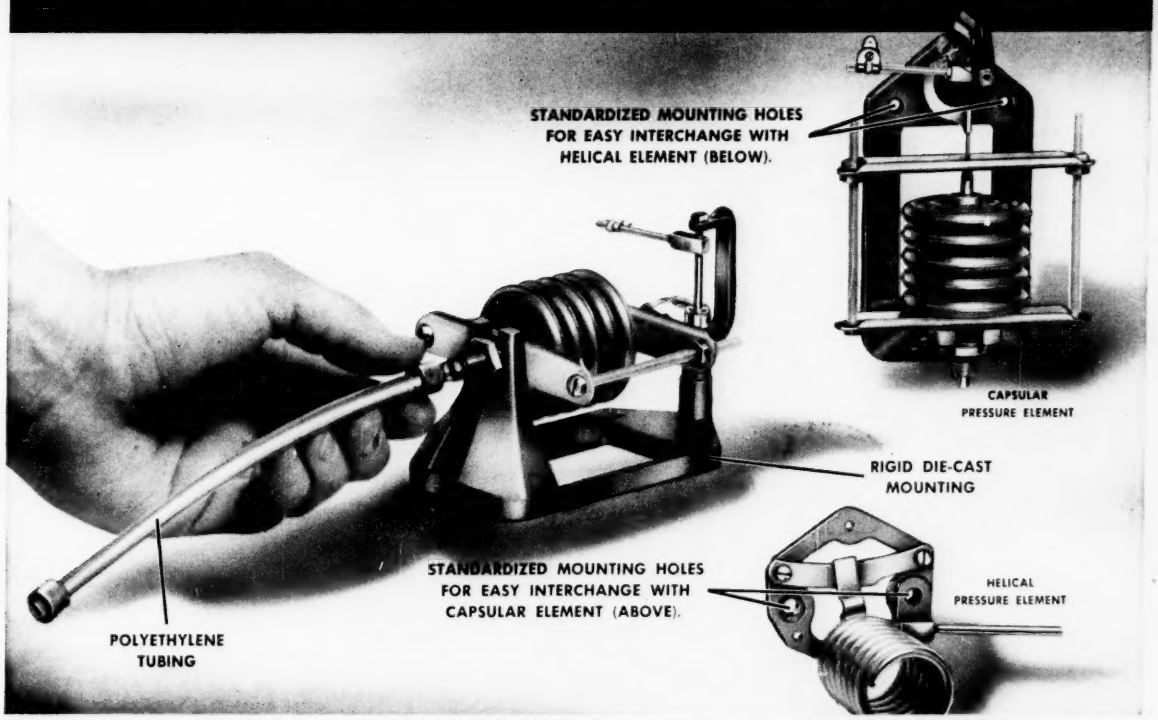
STANDARDIZED MOUNTING HOLES FOR EASY INTERCHANGE WITH HELICAL ELEMENT (BELOW).
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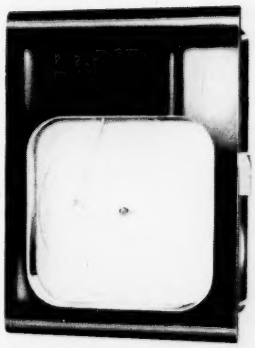

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